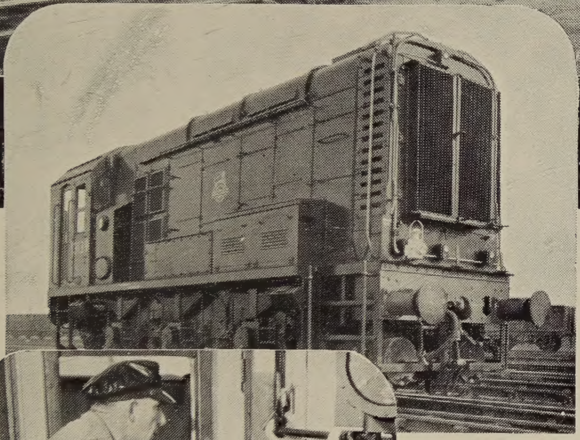
VOL. XXXIII. — No. 3. MARCH 1956

Monthly Bulletin of the International Railway Congress Association

(English Edition)

New Series of B.R. STANDARD DIESEL SHUNTING LOCOMOTIVES



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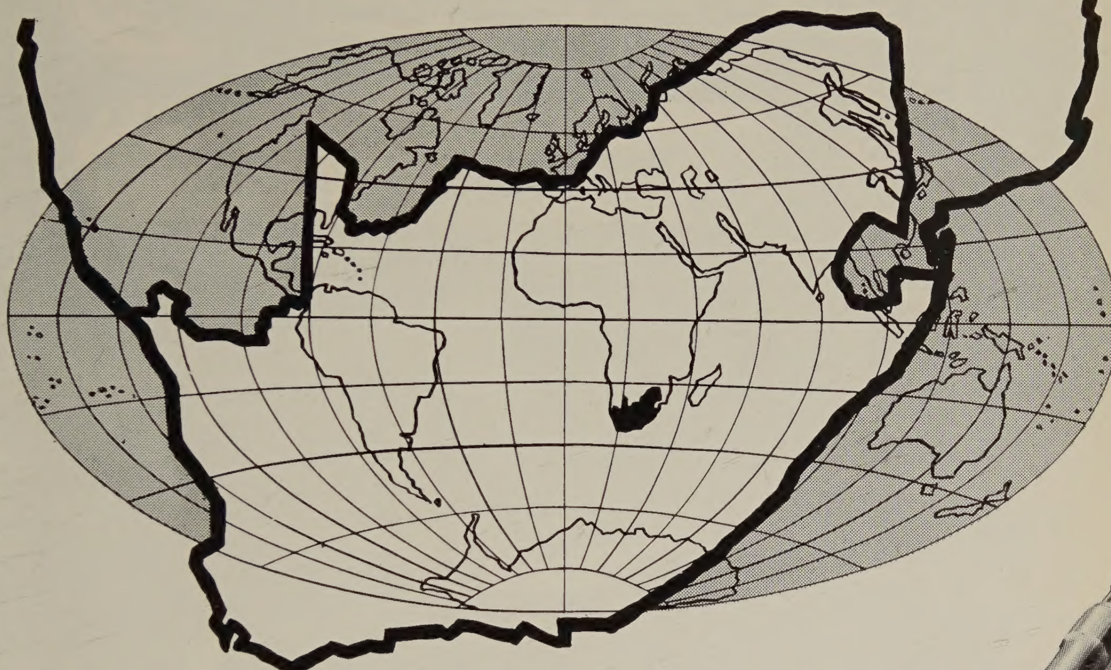

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Alphabetical Index of Advertisers

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Permanent Commission of the International Railway Congress Association

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Vol. XXXIII. — No. 3. March 1956.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .431 .72]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(THE HAGUE-SCHEVENINGEN, 1956).

QUESTION 2.

In a system of standard, narrow or broad gauge lines which has Diesel traction for shunting and for main line working, what are the conditions governing :

1) the choice of the characteristics and kind of transmission ;

2) the most economical organisation, maintenance and operation.

Research into savings that might be possible in comparison with steam traction.

REPORT

(Austria, Belgium and Colony, Bulgaria, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Germany (Federal Republic), Greece, Hungary, Indonesia, Italy, Luxemburg, Netherlands, Norway, Poland, Portugal and overseas territories, Rumania, Spain, Sweden, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia),

by R. Biais,

Ingénieur en Chef, Chef du Service du Matériel et de la Traction de la Région du Sud-Ouest de la Société Nationale des Chemins de fer français.

INTRODUCTION.

The questionnaire upon which the present report was based was prepared in collaboration with Mr. R.-F. Harvey, Chief Operating and Motive Power Officer, British Transport Commission, the Reporter for the English speaking countries. Out of the 80 Administrations or Organisations to which this questionnaire was sent, 26 were good enough to reply. Most of them replied at length and took great pains to explain the theoretical or practical considerations which led them to decide how to deal with such and such a problem. We wish to express our thanks to these Administrations. Though some of them were not able to reply to all the questions asked, in view of the newness of their Diesel installations, we do

not wish to overlook them in expressing our thanks.

It must be admitted, and we wish to apologise for the fact in these introductory words, that the questions were very numerous. Because this is such a vast question, it appeared to us that by so doing, the multiple aspects of the problem would be more clearly stressed and in fact it was better to ask a lot of questions than merely insist upon the most important.

This is the solution upon which we based this present report. Certain questions have been grouped together, and others presented in a slightly different form from that given in the questionnaire; some of them have been left out.

First of all we asked, to clarify the position, regarding actual experience, the different Administrations to make their position as regards the problem of dieselisation [1] clear.

In selecting the characteristics, first of all we were at pains to ascertain the opinion of the various Administrations on the problem of the power installations, and consequently upon the number of classes of locomotives needed. Then further details were requested concerning such and such a point in order to ascertain the advantages, both economic and technical. The question of the method of transmission was particularly carefully gone into from this angle.

As regards the organisation of the services and the working, we wanted to make quite clear the new aspects of Diesel traction compared with former methods of traction.

As regards maintenance, the questionnaire was so worded as to make differences in maintenance policy stand out quite clearly. Moreover, it was a question of knowing whether the steam traction maintenance installations could be used or not, and if so, what alterations were necessary.

As regards the economic aspect of the question, we asked the Administrations to distinguish those considerations of an essentially economic nature which led them to adopt dieselisation. We also wanted to know if in every case the use of Diesel traction fulfilled the hopes raised by the preliminary studies; what expectations experience had confirmed; what unexpected results had cropped up.

It must be recognised that it was this final portion of the questionnaire which it was most difficult to answer, as the use of Diesel working was still too recent on most of the railways. Moreover, costs are constantly varying in relation to each other. For this reason certain Administrations were not able to give us all the factors we required for this problem of economics. This is also the reason why it was not possible to bring out the whole of the conclusions which might be useful.

* * *

The Administrations, who replied to the questionnaire, are referred to in the present report as indicated in the following table :

In addition :

The Congo Light Railways Company;

The Rhaetian Railways (Switzerland);

The Hungarian State Railways;

The Viet-Nam Railways,

where the problem of Diesel traction is still in its preliminary stages, were good enough to inform us of their first results or future hopes, and these have been taken into account in the wording of the present report.

The Departmental Railways (France), although they have very little Diesel stock,

(1) This word has not yet been accepted in international usage. Moreover it already has a rival in the word « dieselification » which is favoured by some. We have adopted « dieselisation » simply because we think it sounds better.

Administration	Designation
Swedish State Railways	SWEDEN
Danish State Railways	DENMARK
Netherlands Railways Company	N. S.
Deutsche Bundesbahn (Western Germany)	D. B.
Belgian National Railways Company	S. N. C. B.
Luxemburg Railway Company	LUXEMBURG
French National Railways Company	S. N. C. F.
Österreichische Bundesbahn (Austria)	Ö. B. B.
Italian State Railways	F. S.
Portuguese Railway Company	PORTUGAL
Algerian Railways	ALGERIA
Tunisian Railway Company	TUNISIA
Gafsa Railways	GAFSA
Morocco Railways	MOROCCO
Franco-Ethiopian Railways from Djibouti to Addis-Abeba	ADDIS-ABEBA
French Overseas Railways Central Office (Congo-Ocean, Cameroons, A.O.F.)	O. C. F.
Colonial Transport Office	OTRACO

replied to certain points in the questionnaire.

Finally, the following Administrations advised us that they were not in a position to reply to the questionnaire :

Lower Congo-Katanga Railways;
Belgian National Light Railways;
Swiss Federal Railways;
Mediterranean-Niger Railways.

FOREWORD.

The question set was worded as follows :

In order to obtain a better idea of the existing situation in regard to dieselisation, we have considered it advisable to request each administration to which a questionnaire is sent, to be good enough, firstly, to reply to the two initial questions, as follows :

1\. — a) *Number of Diesel locomotives in normal service, on trial, or under examination according to the type of service operated :*

— *shunting;*

— *train working (passenger, freight, mixed traffic);*

— *mixed service (train haulage and shunting).*

b) *What are the essential characteristics of the principal types of these various locomotives :*

— *type;*
— *weight per axle;*
— *method of transmission;*
— *maximum speed;*
— *tractive effort/speed curve;*
— *number of Diesel motors;*
— *nominal power and speed of traction motor/motors.*

2\. — *Brief summary of the characteristics of the system, or part of system, over which the service is operated entirely or partially by Diesel :*

— *structure (gauge, weight of rail, track characteristics);*
— *gradient profile;*
— *characteristics of the working;*
— *nature and intensity of traffic.*

The essential data received in reply to this preliminary question are summed up in Table I hereafter.

TAB

PREA

The present position

1 a	Sweden				Denmark		N. S.			
Number of Diesel locos in normal service :	less than 300 HP		more than 300 HP							
Shunting	300		50		25 *		125 *			
Train services	—		50		11		6 *			
Mixed services	—		50		27		323 *			
Number of Diesel locos on trial or being studied :										
Shunting	—				—		—			
Train services	—				22		—			
Mixed services	—				2		—			
1 b										
Essential characteristics of the principal types :						pro-posed				
Designation	Z6	V3	T2	T4			700	2 200	2 400	2 60
Diagram	B	C	D		AIA-AIA	AIA-AIA	C	BB	BB	AIA AIA
Maximum weight per axle	14	16.7	14.2	14	—	18	17	18	15	18
Type of drive *	H	H	H	E	E	E	E	E	E	E
Max. speed km/h	50	50	80	100	133	133	32	100	80	100
No. of engines	1	1	1	1	1	1	1	1	1	1
Power of the engine	240	430	800	1 310	1 720	2 000	400	900	850	1 25
Nominal speed	700	600	750	800	800	835	520	1 100	1 500	600
2										
Summary characteristics of the track :										
Gauge (N = 1.435 m)	N				N		N			
Weight of rails (in kg per m)	32 to 41				45 to 60		38 to 46			
Maximum gradient (in mm/m)	17				7		—			
Characteristics of Diesel operating	As a supplement to electric traction on feeder lines				Partial		Partial			
Kind of traffic worked	Shunting and secondary lines				Shunting and light freight traffic. Light and long distance passenger traffic		Shunting, freight and pass enger on non-electrifie lines			
* M = Mechanical H = Hydraulic E = Electrical					* including small locomotives		* including the locomotive now under constructio			

L E

gards Diesel traction.

D. B.			*S.N.C.B.*				*Luxemburg*		*S.N.C.F.*			
94			11				13		148			
15			—				—		—			
—			—				—		80			
—			106				—		—			
—			91				—		35			
—			—				—		167			
V36	V80	V200	270	252	201	202 203	600	800	030 D A	040 D E	060 D A	pro-posed 060 D B
C	BB	BB	BB	C	BB	CC	C	BB	C	B B	C C	C C
13.4	15	19	21	19.5	22	18	17	18	17	17	20	17
H	H	H	E	H	E	E	H	E	E	E	E	E
30.60	100	140	30.50	30.50	120	120	38.67	70	60	80	75	130
1	1	2	1	1	1	1	1	1	1	1	1	2
360	1 000	1 000	700	550	1 750	1 720	600	800	510	600	2 000	900
600	1 500	1 500	650	680	625	835	550	800	890	900	710	1 500
N			N				N		N			
—			52				—		38 to 46			
15			16				—		15 to 26			
Partial			Partial				Partial		As a supplement to electrification on feeder lines			
Shunting and fast passenger services			Shunting and heavy freight Semi-through passenger services				Heavy shunting		Shunting and secondary lines			

TABLE

PREAM

The present position as

1 *a*	Ö.B.B.		F.S.				Portugal		
Number of Diesel locos in normal service :									
Shunting	15 *		—				6		
Train services	—		—				29		
Mixed services	20		49				12		
Number of Diesel locos on trial or being studied :									
Shunting	30 *		—				17		
Train services	—		25				—		
Mixed services	—		15				—		
1 *b*									
Essential characteristics of the principal types :				pro-posed	pro-posed	pro-posed			
Designation	2 060	2 045					1 101	1 301	1 521
Diagram	B	B B	B B	B B	B B	B B	B B	AIA-AIA	AIA-AIA
Maximum weight per axle	13.5	17.5	15.5	16.5	16	16	10.3	16	19
Type of drive *	H	E	E	E	H	M	E	E	E
Max. speed km/h . . .	30.60	90	70	100	100	100	56	120	120
No. of engines	1	2	2	2	1	2	2	2	1
Power of the engine . .	200	500	300	800	1 600	600	190	675	1 600
Nominal speed	1 500	1 350	1 200	1 500	960	1 200	1 000	1 100	1 000
2									
Summary characteristics of the track :									
Gauge (N = 1.435 m)	N		N				1.66 m		
Weight of rails (in kg per m)	30 to 40		36				40 to 50		
Maximum gradient (in mm/m)	—		22				—		
Characteristics of Diesel operating	As a supplement to electrification on feeder lines		As a supplement to electrification on feeder lines				Partial		
Kind of traffic worked . .	Shunting, freight, passenger, semi-through services on secondary lines * small locomotives, type 2060		Freight and passenger of average tonnage				Shunting, freight traffic and all kinds of passenger traffic		

* M = Mechanical
H = Hydraulic
E = Electrical

I *(Continued.)*

BLE

regards Diesel traction.

Algeria Gauge standard	*Algeria* Gauge narrow	*Tunisia* Gauge standard	*Tunisia*	*Tunisia* Gauge narrow	*Gafsa*	*Morocco*
43 *	15 *	—		—	—	15
76	9	4	33 *	2	17	24
—	—	—		—	6	—
—	—		16 *		—	—
—	—		—		—	8
—	—		—		—	—

Algeria				*Tunisia* gauge N	*Tunisia* gauge E	*Tunisia* gauge N	*Gafsa*		*Morocco*		
400 DEA BB	040 DC AIA-AIA	040 DA AIA-AIA	040 DD AIA-AIA	040 DA BB	040 DA BB	040 DA AIA-AIA	301 BB	201 BB	030 DD C	040 DB AIA-AIA	040 DA AIA-AIA
14.3	17.5	20	18.5	13.8	13.5	21	10	13	18	19	21
E	E	E	E	E	E	E	E	E	E	E	E
30	90	96	120	90	70	96	56	70	55	96	96
2	1	1	1	1	1	1	2	1	1	1	1
170	1 000	1 500	1 600	620	620	1 500	190	600	450	750	1 500
1 000	625	625	1 000	800	800	625	1 085	800	1 500	625	625

Algeria		*Tunisia*		*Gafsa*	*Morocco*
N	1 m and 1.05 m	N	1 m	1 m	N
30 to 40	20 to 25	30 to 46	30 to 36	25 and 36	46
25	25	20	20	15	15
completely on non-electrified standard gauge lines	partly on narrow gauge	Partial		Total	Partial
	lines for all kinds of traffic	Exclusively for freight traffic		All traffic	Shunting, freight traffic and all kinds of passenger traffic

Algeria: * including small locomotives

Tunisia: * the locomotives can be used on both standard and narrow gauge lines by changing their bogies

N = standard E = narrow

TABLE I *(Continued.)*

PREAMBLE

The present position as regards Diesel traction.

1 *a*	*Addis-Abeba*		*O. C. F.*				*OTRACO*		
Number of Diesel locos in normal service :									
Shunting	—		—				25 *		
Train services	—		87				28		
Mixed services	12		26				2		
Number of Diesel locos on trial or being studied :									
Shunting	10		—				4		
Train services	—		36				4		
Mixed services	6		8				—		
1 *b*									
Essential characteristics of the principal types :		pro-posed							
Designation	SLM								
Diagram	AIA-AIA	B B	B B	AIA-AIA	B B	C	B B	C C	C C
Maximum weight per axle	8.4	13.5	13.5	16	13.5	13.5	10.7	16	15
Type of drive *	E	E	H	E	E	E	E	E	E
Max. speed km/h	65	70	80	78	70	50	56	80	80
No. of engines	1	1	1	2	1	1	2	1	1
Power of the engine	580	850	720	675	730	300	190	1 750	1 500
Nominal speed	750	1 500	1 250	1 100	1 500	1 500	1 000	625	1 000
2									
Summary characteristics of the track :									
Gauge (N = 1.435 m)	1 m		1 m and 1.06 m				1.06 m		
Weight of rails (in kg per m)	27		30				33 to 40		
Maximum gradient (in mm/m)	20 to 30		15				17		
Characteristics of Diesel operating	Partial		Partial				Total		
Kind of traffic worked	Colonial type traffic		Colonial type traffic				Colonial type traffic		
*M = Mechanical H = Hydraulic E = Electrical							* including small locomotives		

Two comments must be made :

— the stock of Diesel locomotives on each railway does not include in principle, unless special mention is made of the fact, the small locomotives used for shunting in the yards, depots and shops (generally of less than 150 to 200 HP). These small locomotives are not left out of the questionnaire properly speaking, nor have they been omitted from the replies to the questions concerning them;

— in analysing the essential characteristics of the chief types of locomotives, we have kept to a limit of 4 types, even in the case of railways having more. It must be remembered that this foreword is only intended to give a rapid survey of the present position on each Railway as regards dieselisation.

It must be pointed out that the powers given in this table (as in the actual text of the report) are the nominal powers of the Diesel engines.

CHOICE OF CHARACTERISTICS.

1. — *If the operation of a district calls for a high degree of power, do you prefer high power locomotives or do you consider it more advantageous to use lower power locomotives coupled together?*

For what reasons?

Most of the Administrations agree that for equal power, the cost of buying and maintaining a single locomotive is lower than the cost of buying and maintaining two locomotives of half the power. But this consideration by itself does not lead to the conclusion that it is more advantageous to use locomotives of great power. Other factors come into play in deciding the solution.

The first is the traffic on the railway where Diesel traction is to be used. When it is question of lines which allow average or heavy train loads to be hauled from one end to the other without dividing the train, the Railways are in favour of powerful locomotives (Denmark, S. N. C. B., Portugal, Morocco, OTRACO). On the contrary, those railways whose lines have varied and difficult profiles prefer to divide up the power and use assisting locomotives at the difficult points of the line (Tunisia, Gafsa, Addis-Abeba, O. C. F.).

Then there is the question of flexibility of working. Certain Administrations (Sweden, N. S., Luxemburg, S. N. C. F.) lay great stress on adapting the power supplied as closely as possible to the traffic to be worked. They are therefore in favour of engines of average power used as single units in most cases and as multiple units when the tonnage or speed of certain trains render this necessary. The S. N. C. F. considers that by so doing, it gains « both as regards the user of the locomotives, the cost of the engines to be purchased, and consequently the capital to be invested for a given dieselisation programme ».

Finally, there is another factor which must be taken into account in Europe and countries under European influence. This is that in the present stage of Diesel technique in such countries, and taking the allowable axle loads into account, a power of 2 000 HP per locomotive appears to constitute the utmost reasonable limit. This leads *ipso facto* to dividing up any power required over and above 2 000 HP [1] (for heavy freight trains of 1 800 to 2 000 tons on gradients of 10 to 13 mm per m = 10 to 13 $^{0}/_{00}$).

2. — *If you favour the principle of using coupled locomotives, do you consider that there should be corridor connection between the two units?*

If so, for what reasons?

Those Administrations, which actually

[1] It should be noted, however, that the D.B. is studying a type CC locomotive of 3 200 HP which has two 1 600 HP engines.

make use of multiple units with a single crew for two locomotives, replied in the affirmative. The reasons generally put forward are :

— possibility of controlling the equipment of the second locomotive by the assistant of the driver;

— ease with which steps can be taken should anything go wrong en route.

On the N. S. there is only one driver, even in the case of two locomotives coupled together as a multiple unit. That is why there is no communication between the two units.

Those Administrations who only make use of two locomotives for double heading, with a driver on each locomotive, in general do not stipulate intercommunication between the two locomotives. However, certain African Railways think intercommunication is necessary even in this case, owing to the technical level of the drivers as regards coping with breakdowns. In this way the chief driver, when he has a second locomotive, can get from one locomotive to the other. The driver can also assist the driver of the second locomotive (O. C. F., OTRACO).

Briefly, it can be stated that when the locomotives are used as multiple units, except in those cases where they are both driven by one man, it has been recognised that it is necessary to have intercommunication between them. This has also been considered advisable at times in the case of double heading.

No European nor African railways use locomotives made up of a number of non-independent units as is the case in the U. S. A.

3. — *Do you consider that a single type of locomotive could, satisfactorily, cope with a varying range of gradients, loads and speeds in the haulage of different categories of trains; if not, how many types do you consider should be constructed :*

a) *for main lines?*

b) *for secondary lines?*

What do you consider should be their power? How do you justify your choice?

The following table summarizes the replies received from the Administrations. Some of them have adopted a single type of locomotives to haul different categories of trains; others have adopted or intend to adopt more than one type.

It will be noticed that the railways in the first group are outside Europe. In these countries, it has been found possible to make the load and speed conditions compatible, provided the one or the other is sacrificed, usually the second. It must also be remembered that most of these railways are narrow gauge systems.

In the other cases, where commercial needs make it necessary to have the maximum loads and speeds, at least two types have been retained for the main and secondary lines (though there may be no clear distinction between the two of them).

There is therefore in general :

a) one or two types of locomotives intended for average traffic on secondary lines. The scale of powers is as follows :

600- 700 HP;

700- 800 HP;

1 000-1 400 HP;

b) one type of locomotives (sometimes 2 [S. N. C. F.]), intended for fast or mixed traffic on the main lines. The power scale is then 1 500-1 800 HP or slightly higher : 2 000 HP.

4. — *How do you propose overcoming the problem of heating in the case of Diesel locomotives operating a passenger service? What reasons have you for this preference?*

Is the system installed on the locomotives or on a special vehicle?

Power	550 600	600 700	700 800	1 000 1 400	1 400 1 500	1 500 1 800	2 000 and more
1. *Administrations who have adopted a single type of locomotives.*							
Tunisia	......	●	......	......	......	......	......
Gafsa	●	......	......	......	......	......	......
Morocco	......	......	......	......	●	......	......
Addis-Abeba	●	......	......	......	......	......	......
O. C. F. (Cameroons)	......	......	●	......	......	......	......
OTRACO	......	......	......	......	●	......	......
2. *Administrations who intend to adopt more than one type of locomotives :* S = locomotives intended for secondary lines and if necessary for shunting; P = locomotives intended for the main lines.							
Sweden	......	......	.S	.S	......	......	......
Denmark	......	......	......	.S under study	......	.P	......
N. S.	......	......	.S	.P and S	......	.P	......
D. B.	......	......	......	.P	......	.P under study	.P
S. N. C. B.	......	......	......	.P and S	......	.P	......
Luxemburg	......	......	.S	......	......	.P	......
S. N. C. F.	......	.S	.S	......	......	.P	.P
Ö. B. B.	......	......	......	.P and S	......	.P under study	......
F. S.	.S	......	......	.S	......	......	......
Portugal	......	......	.S	......	.P	......	......

The solution adopted almost unanimously is a self-contained steam generator installed on the locomotive itself. The reason for this is that most passenger coaches are equipped for steam heating. Such equipment is not subject to deterioration through freezing or other outside influences. Service and maintenance are simple. They are generally preferred to any other system (hot water or hot air heating). The heating boiler is often automatic; it is run on gas oil.

Certain Railways, however, have had to solve the problem of heating in a different way. In Morocco, for example, passenger trains only have to be heated over a period of not more than 4 to 5 months, and the solution of gas-oil fired boiler vans has been preferred, in spite of the nuisance when trains have to be turned. In Sweden, 95 % of the passenger stock is equipped with electrical heating and the arrangement to be used in the future is an electric generator mounted on the locomotive and driven by a 300 HP Diesel engine.

5. — *What, in your opinion, should be the power of Diesel locomotives for the various types of shunting to be performed : breaking down of trains by the gravity/hump method-work in sidings — transfer of sets of wagons — shunting at small station, warehouses, workshops or depots?*

On the basis of these considerations, how many classes of locomotives are provided or will be provided for shunting?

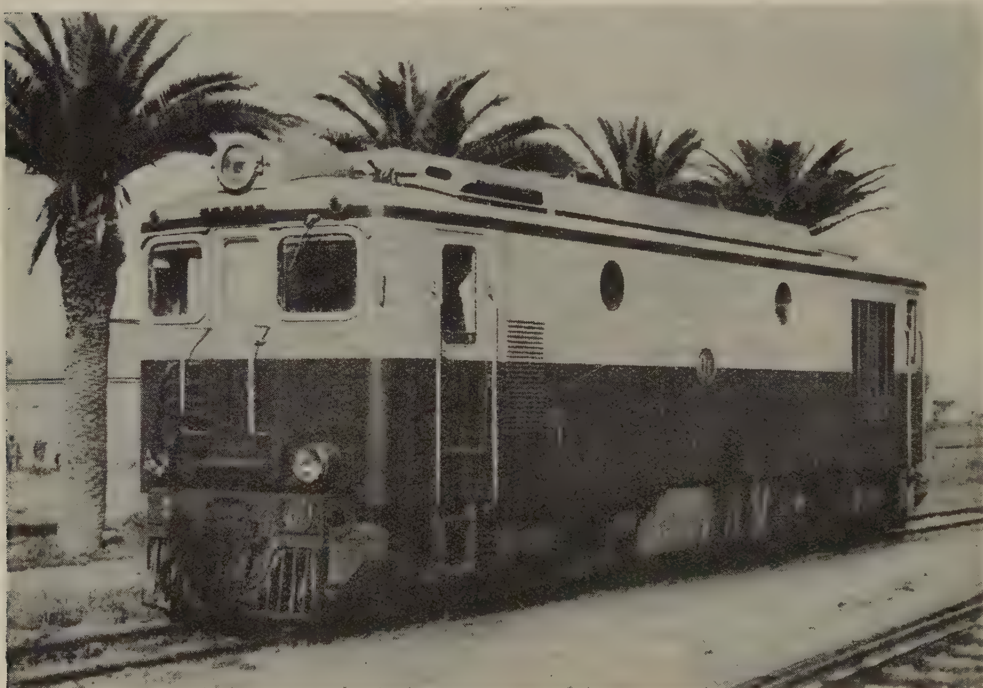
The Administrations are commonly agreed that the powers required for shunting come under three distinct groups [1] :

— shunting in small yards, stores, shops or depots : 100 to 200 HP;

— hump shunting and branch line services [2] : 400 to 600 HP;

— transfer services [2] : 600 to 800 HP.

On this basis, the Administrations have adopted or intend to adopt 1 to 4 classes of locomotives corresponding to the three scales of power defined. Their choice is shown in the following table :



Tunisia. — Type BB narrow gauge Alsthom-Sulzer locomotive. Can be used on standard gauge track by changing the bogies. One 620 HP 6 L DA 25 Sulzer engine, 4 stroke, supercharged. Electric drive by 4 traction motors. Top speed : 74 km (43 miles)/h. Weight per axle 13.5 t.

6. — *What factors do you think should be taken into consideration when selecting the scope of operation or the period of autonomy for Diesel locomotives?*

(1) In this connection, mention may be made of a detailed study carried out on the D.B. which showed the upper and lower load limits admissible in service (power in HP at the drawbar) :

	Light services.	*Heavy services.*
Backing up	430	600
Shunting over the hump .	340	570
Transfer services . . .	500	1 040
Branch line services . .	380	—

(2) And, if necessary, light freight services on secondary lines.

Administrations	Transfer services	Hump shunting	Shunting in stations or shops
Sweden	800	450	300 — 200
Denmark	600	400	170
N. S.	800 (1)	450 — 350	100
D. B.	......	600	100
S. N. C. B.	750	550	350 — 150
Luxemburg	800	600 — 450	150
S. N. C. F.	760 — 600	510 — 400	150
Ö. B. B.	800	500	200
F. S.	600	350 — 250	120
Portugal	800 to 600		200
Algeria	......	400	150
Tunisia	......	300	......
Gafsa	......	350	150
Morocco	......	450	200
OTRACO	800	400	200

(1) The 800 HP type is allocated by the N. S. to shunting where the hump is more than 2.50 m (8' 2 $^{7}/_{16}$") high.

To determine the radius of action of a main line locomotive, it is necessary to consider either the longest section to be worked without a stop for refuelling, or the longest distance between adjacent fuelling points. The capacity of the gas-oil tanks depends upon the longest distance calculated in this way and the engine consumption per kilometre (i. e. upon the kind and load of the trains hauled).

The replies received show that the fuel tanks usually installed upon the locomotives allow of a radius of action of the order of 800 to 1 000 km (500 to 620 miles). It also appears that such radii of action usually meet requirements and that no particular difficulty has been experienced in fitting the locomotives with tanks of this capacity.

However it should be noted that the D. B. requires locomotives to be able to run 2 000 km (1 240 miles) without refuelling in the case of the fast long distance passenger trains (hauled by V 200 locomotives).

In the case of a shunting engine, this must be self-contained for a period corresponding with the time lag between two returns to the neighbouring depot : this varies from 3 days (D. B., Gafsa, OTRACO) to a week (Sweden, Denmark, S. N. C. B., S. N. C. F.).

7. — *What axle arrangements have you adopted or do you propose adopting for :*

— *train haulage on main lines;*

— *shunting.*

Have these arrangements been influenced by the general characteristics of the track structure?

In the case of main line locomotives, the axle arrangements adopted are A1A-A1A, BB and CC. Exceptionally, Sweden uses the arrangement 1C1 and 1D1.

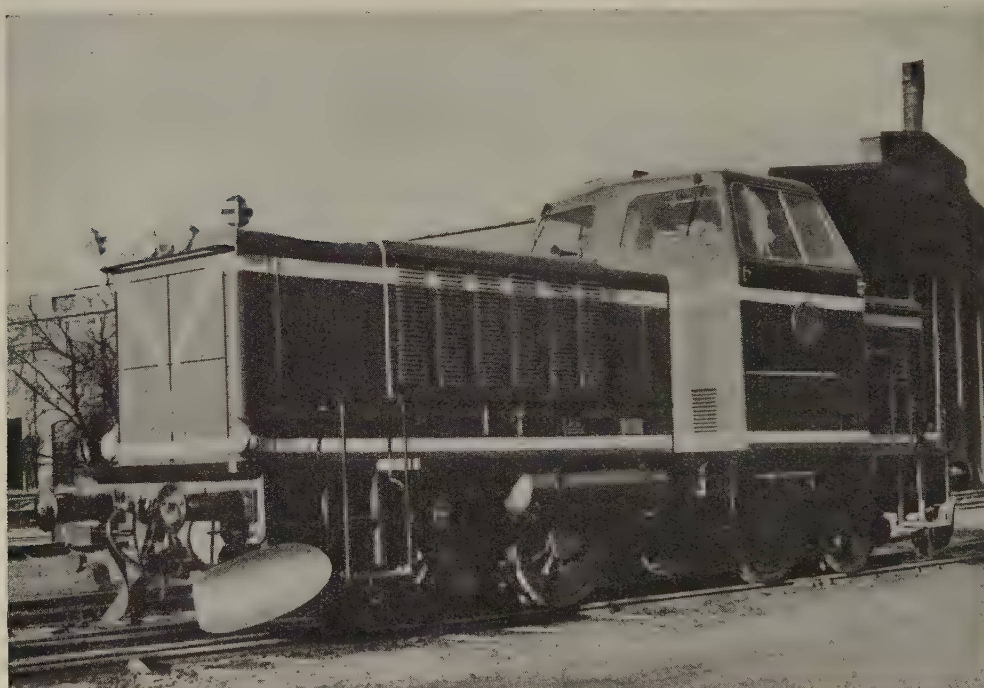
The Administrations, who have adopted the type A1A-A1A, have been led to do so by the powers in play and the permissible axle loads for the permanent way (Portugal, Algeria, Morocco, Addis-Abeba).

Some of these Administrations (Algeria,

Addis-Abeba) are now strengthening their permanent way : in future they will make use of the BB or CC types.

The BB type is the most usual type for locomotives of average power (up to 1 700 HP). This has been adopted wherever the permanent way has not limited the axle load to a value incompatible with the power installed (N. S., D. B., S. N. C. B., S. N. C. F., Ö. B. B., F. S., Tunisia, Gafsa, O. C. F.). It is also commonly agreed that the arrangement BB is less severe upon the track than any other wheel arrangement. There is therefore a saving both in the wear of the track and the wear of the tyres, i. e. in the times locomotives have to be taken out of service to re-profile the tyres.

Finally, the CC type is adopted or under consideration by those Administrations who are working towards increasing the power of their locomotives (1 750 HP Diesel-electric locomotives of the S. N. C. B.; proposed V 320, 3 200 HP locomotive of the D. B., 1 800 and 2 000 HP locomotives under construction on the S. N. C. F.).



Sweden. — Type D, T 2 locomotive for secondary lines and heavy shunting. One 800 HP engine. Hydraulic drive. Top speed : 80 km (50 miles)/h. Weight per axle : 14.2 t.

Locomotives for shunting or mixed services generally are total adhesion locomotives and a B, C or D axle arrangement is used, according to the power installed. Type B is for locomotives of less than 200 to 300 HP; the type D for heavy shunting engines of 700 to 800 HP. A few administrations (N. S., S. N. C. B., Luxemburg, S. N. C. F., Ö. B. B.) have also retained the type BB for mixed locomo-

tives of a certain power. The S. N. C. F., after a trial of six wheeled locomotives coupled by rods, states that owing to the bad effect of this type of locomotive upon the track, it is going to adopt the BB type wherever the B type has proved insufficient.

What type of engine do you prefer — slow or fast — (two stroke or four stroke)?

Today the Administrations generally prefer to use only one engine per locomotive. Breakdowns of the engine now being extremely rare, the need for having

S. N. C. F. — Type CC, 060 DA locomotive intended to haul heavy goods trains on the Paris Ceinture Railway. One 2 000 HP, 12 cylinder 12 L DA 28 Sulzer engine, 4 stroke, supercharged. Electric drive by 6 traction motors. Top speed : 75 km (46 miles)/h. Weight per axle : 20 t.

8. — *In the case of a particular locomotive, do you think it preferable to use a single engine or several engines of lower power?*

What are the reasons for your answer, taking into consideration the cost of construction, maintenance costs and possible adverse effect on operating reliability?

two engines on a Diesel locomotive to meet any trouble in working is no longer essential. This point of view is not however shared by the Gafsa Railway who, with a single track line through the desert, consider it most important to be able to run on one only of the two engines with electric drive. This obviously is a very special case.

The choice of the solution of a single engine is dominated by considerations of the cost price (both for the actual engine and its auxiliaries) and the cost of maintenance, which is lower.

Above 1 500-1 600 HP, account must be taken of the fact that a single engine is only possible with relatively slow engines. In the present stage of technical development in Europe such engines are only made in small numbers; they weight a great deal and their cost is high. Moreover, they require very large generators and the weights of the components (engine block, couplings, etc.) involve the use of lifting gear at the maintenance centres.

Nevertheless, the S. N. C. F. has ordered 200 CC Diesel-electric locomotives fitted with a 2 000 HP engine. It is hoping, on the other hand, to save on the auxiliary equipments, which, though dearer, are only half as many, and on maintenance, as the large slow engines should only require attention at much greater intervals.

The engine most frequently used is the 4-stroke, either supercharged or not, slow or high speed. The N. S. express a point of view that is fairly widely held when they state that they prefer a semi-slow engine (800 to 1 000 revs. per min.) but unfortunately the power required often makes it necessary to accept a faster turning engine in view of the maximum allowable weight per axle.

Two stroke engines have been used in Sweden, on the N. S., Ö. B. B. and in Luxemburg. The S. N. C. B. and Denmark are also proposing to put such engines into services. These Administrations consider that two stroke engines are now just as reliable as four stroke; they have the advantage of being lighter and simpler to maintain. They state however that they have not sufficient experience to give them a definite preference.

9. — *Do you consider it expedient to investigate the use of lower efficiency Diesel engines which are more simple, less costly, do not require a high standard of maintenance labour or such frequent workshop attention, but which is offset by a lower degree of engine performance ?*

— *Have you investigated construction methods that would allow the maximum possible facilities in maintenance by the standard exchange of engine parts, also the standardisation of a large number of component parts (pumps, injectors, self-starters, compressors, radiators, brakes, lighting equipment...) ?*

Many Administrations have preferred a simple Diesel engine, which is not overloaded, and robust. This tendency is particularly apparent in countries outside Europe where the qualifications of the labour available for maintenance and difficulty of getting stores gives rise to serious problems. The Algerian Rys. state : « We find that maintenance costs vary to a considerable extent, being sometimes twice as great, from one series to another, whereas the other factors in the cost only show a maximum variation of 20 %. The factor, maintenance, must therefore be the one to receive our attention in the first place. » All these Administrations insist, however, upon the fact that even with simple engines, it is essential to keep a close check on the quality of the maintenance personnel.

On the opposite side, certain European countries where specialised labour is available, consider that the efficiency of the engine must not be deliberately sacrificed (Denmark, Luxemburg).

In the case of the D. B., there is no reason for thinking even after several years of tests, that the specific simplicity of an engine and the maintenance costs are closely interconnected. Though they agree that the cost of one overhaul by itself is lower in the case of a simple engine, they are not sure that the kilometric cost is better, seeing that « a more complicated engine may be so designed

that in certain cases it is possible to get a much greater mileage from it between two general repairs ».

The S. N. C. F. express a similar point of view : « Simplicity and efficiency are two independent factors when it is question of well designed engines. » This Administration thinks that « it is necessary above all to look for a high standard of manufacture and repairs rather than simplicity of design which has no effect upon the behaviour of an engine. »

To sum up it appears that simplicity of design is essential where there are maintenance difficulties, both as regards labour and spares. In the contrary case, more complicated and delicate engines can be designed whose maintenance cost per kilometre will nevertheless be lower.

In every case, it is desirable to obtain on any given railway standardisation of the greatest possible amount of equipment in agreement with the different makers [1]. This point of view is unanimously expressed and the Administrations who are most in favour of it are just those who have to deplore the absence of standardisation.

D. B. — Type BB, V 80 locomotive for passenger services in the Francfort and Nuremberg regions. One 800 or 1 000 HP, 12 cylinder Daimler-Benz Maybach or Man engine. Voith or Maybach drive. Top speed : 100 km (62 miles)/h. Weight per axle : 15 t.

[1] This agreement may be limited as on the D.B. to the adoption of certain common dimensions which make certain components from different makers strictly interchangeable (Diesel engine, transmission, mounted axles, heating boilers, fuel pumps, etc.).

10. — *On Diesel locomotives, do you advocate the installation of a single driving cabin in the centre, or a cabin at each end, or a single cabin only at one end?*

— *for shunting locomotives;*

— *for locomotives hauling trains.*

All the Administrations agree that a single driving compartment is the best in the case of shunting locomotives, preferably located in the centre.

This is the solution also laid down for main line locomotives for secondary lines, in so far as good visibility can be assured, by lowering the bonnet (Sweden, Ö. B. B.) or raising up the drivers's lookout (D. B., S. N. C. F.). The advantages obtained from this solution are : reduction in the weight of the locomotive and its cost price, simplification of controls and their maintenance to a very considerable extent. When the power of the engine is such that the size of the equipment interfers with visibility to such an extent that the engine cannot be worked in reverse, the Administrations agree that as this is essential for the working, there has to be a driving compartment at each end. This arrangement is used in particular on railways where there are heavy locomotives intended for fast passenger services (Denmark, N. S., D. B., S. N. C. B., S. N. C. F., F. S., Portugal). It should be noted that, when locomotives are often used coupled together, a driving compartment at one end is sufficient (Addis-Abeba, OTRACO).

11. — *Do your favour the use of the « dead man's handle » :*

— *for shunting services?*

— *for train haulage services?*

This question has been linked up with Question 16 which deals with working Diesel locomotives with one or two men.

In effect in principle the « dead man's handle » is a device by which the safety measures which are normally the responsibility of the driver's assistant are assured automatically if anything happens to the driver (cutting out, braking). The installation of a dead man's device is therefore closely connected with having only one man on the engine.

This is always the case, except for shunting where certain Administrations willingly agree that the locomotive can be driven by one man only without being equipped with dead man's handle (S. N. C. F., Morocco, OTRACO). In Algeria, it is also allowed on the narrow gauge lines.

On the other hand, certain Railways, though they have two men on their main line locomotives, are in favour of the dead man's handle :

— either because the drivers have a lower standard of training and run a greater risk of being taken ill owing to the difficult climatic conditions (Addis-Abeba, OTRACO);

— or to increase safety on locomotives running at very high speeds and to make it possible in particular for the assistant driver to leave temporarily the driving compartment (S. N. C. F., Portugal).

12. — *What type of fire fighting equipment do you favour for Diesel locomotives? (Portable or fixed, automatic or remote control extinguishers — type of chemical used, gas, foam... etc.).*

The mininmum equipment consists of moveable fire extinguishers in the driving compartment, which may be with carbon dioxide gas, methyle bromide, chemical foam or a fine spray of water.

Certain Administrations (S. N. C. B., S. N. C. F., Tunisia, Morocco, OTRACO) have fitted fixed carbon dioxide gas extinguishers in the motor compartments of their powerful locomotives, which are worked from a distance from the driving compartment or controlled automatically.

Carbon dioxide gas does not leave any

residues which can give rise to arcing; unfortunately it is very soon diluted in the air and is only really effective when the spaces to be protected are really air-tight and not very large.

This is the reason why the S. N. C. F. and D. B. now prefer a water-spraying installation with a hand pump, taking water from the cooling circuit of the Diesel engine.

* * *

CHOICE OF THE TYPE OF TRANSMISSION.

13. — *In the light of your experience and in all investigations made by your administration, what, in your opinion, are the respective fields of use for the various methods of transmission, mechanical, hydro-mechanical, hydraulic and electric? What are their advantages and disadvantages as regards :*

— efficiency in transmitting the different degrees of power actually produced;

— weight, size;

— initial cost and maintenance costs;

— ease of driving the locomotive;

— efficiency;

— operating reliability;

— what difference does the power of the engine make to your conclusions?

a) Table II below sums up the replies received from the Administrations as regards the zones of power within which the different types of drive are used.

It will be noted that on the whole :

— mechanical drive has been adopted for engines of less than 200 HP;

— electrical drive has been adopted for the transmission of powers above 500-800 HP;

— between 200 and 500-800 HP is the domain of hydraulic or hydromechanical drive [1]. This type of drive, moreover, tends to be extended to higher powers and the D. B. is using it up to 1 000 HP and expects to use it at still greater powers (1 600 on the V 320 locomotives).

b) As far as the comparison of these different methods of transmision is concerned, having regard to weight, cost price, maintenance costs, convenience of driving, efficiency and regularity of working, the S. N. C. F. gave the following table in their reply. This has been prepared by putting the best system on the first line and the worst on the third line.

M : mechanical drive;

H : hyraulic drive;

E : electrical drive.

c) The Ö. B. B. which only have hydraulic and electrical drives in use, classify these two methods of transmission in the same way as the S. N. C. F. except as regards maintenance and regularity of working, with the following comments :

Weight.

The advantage of hydraulic transmission is particularly marked in the case of railcars. When the Diesel engine has to drive more than two axles, hydraulic drives involve complicated arrangements whereas with the electrical drive the distribution and arrangement of the engines and components for the individual drive of the axles is easily effected.

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[1] According to the O.R.E. definition a drive is hydromechanical « which contains the hydraulic elements necessary for the proper working of the system but does not transmit the total power over the whole of the scale of speeds ». Accordingly in the case of Diesel locomotives now in service, only the Atlas Diesel DF 1.0 drive of the Z 4 180 HP locomotives of Sweden is hydromechanical. In the rest of the report, this is dealt with as a hydraulic drive.

Weight	Cost price	Maintenance	Convenience for driving	Efficiency	Regularity of working
M	M	E	E	M	E
H	H	H	H	E	H
E	E	M	M	H	M

M = Mechanical drive; H = Hydraulic drive; E = Electrical drive.

Cost price.

The superiority of hydraulic drive is confirmed.

Maintenance costs.

The Ö. B. B. consider that it is the same as far as maintenance is concerned.

Convenience of driving.

The two drives are approximately equal from this point of view.

Efficiency.

Electrical drive has a total efficiency 2 to 4 % higher. At reduced loads, there is less wear. Under heavy loads, at the hourly rating, a limit may be set by the heating of the engines. The full power of the Diesel is used within a zone lying between about 20 % and 95 % of the maximum speed. With hydraulic drive, it is possible to get as low as 15 % of the maximum speed, which is valuable in the case of shunting.

Regularity of working.

The Ö. B. B. give the preference to the hydraulic drive. They state that in practice the only damage to this concerns the gears and cardan shafts. On the other hand, they think the electrical drive is subject to more frequent failure, especially as far as the traction motors are concerned.

d) On the D. B., where extensive studies are being made into hydraulic drive, the following additional advantages are also attributed to it :

— the curve of the tractive effort as a function of the speed of the vehicle follows the ideal hyperbola as closely as possible;

— the tractive effort on starting, which is only limited by the adhesion, can be maintained as long as desired provided the cooling equipment has been made of appropriate size.

On the whole the D. B. show a very marked preference for hydraulic drives which they have decided to adopt for their new locomotives of all powers.

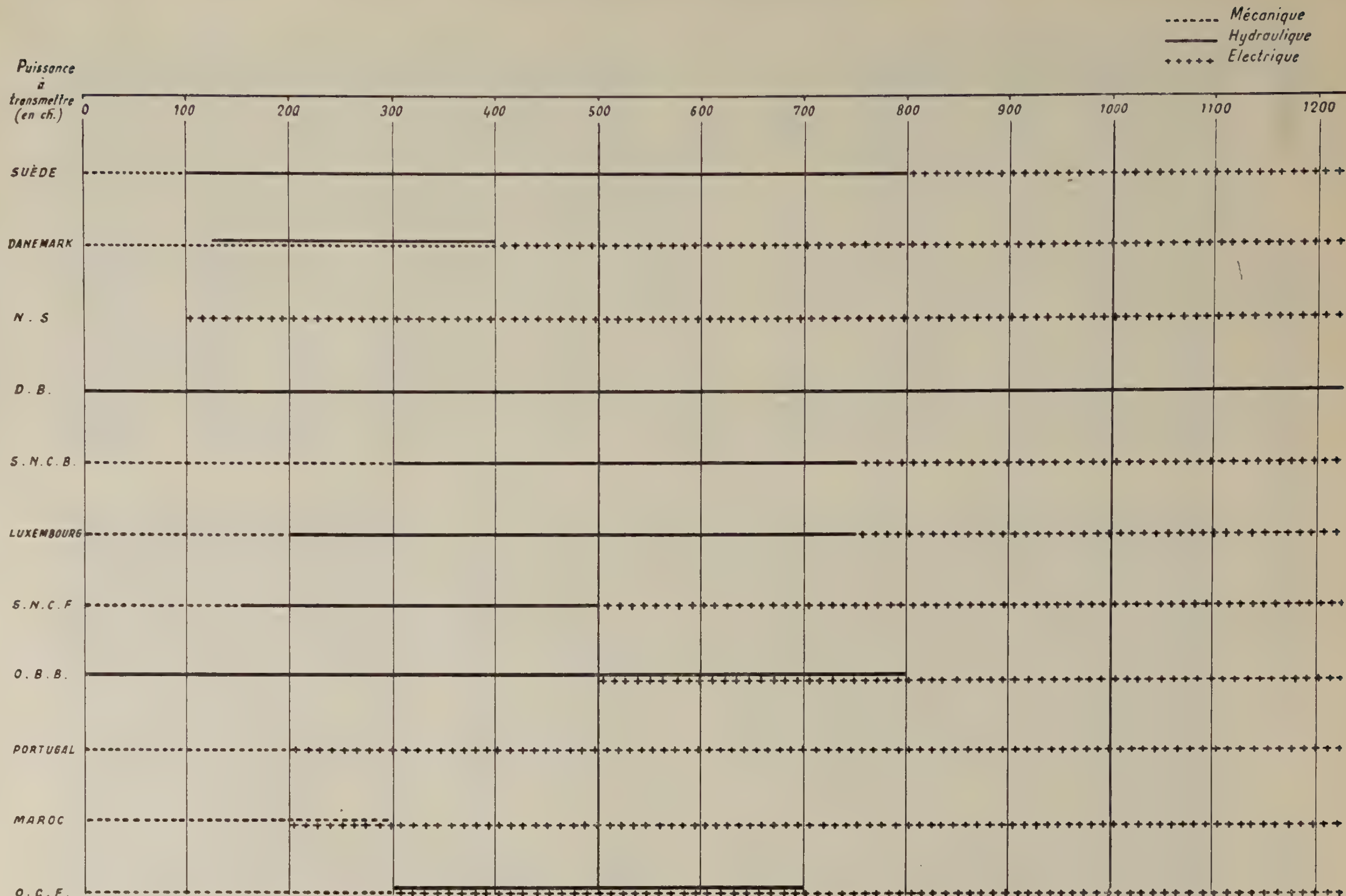
e) There is no doubt under these conditions that the field in which electrical and hydraulic drives compete against each other is extending into the region of the high powers.

The difficulty, however lies, as the S. N. C. B. stresses in realising tested solutions in the case of transmissions with cardan shaft and axle drives on bogie stock with heavily loaded axles (15 t. and over).

14. — *In the case of mechanical, hydro-mechanical or hydraulic transmission, what system of axle drive do you favour in the light of your experience?*

TABLE II.

SCALE OF POWERS OF THE DRIVES.



Explanation of French terms:

- - - - Mécanique = - - - - Mechanical. — ——— Hydraulique = ——— Hydraulic. — — — — — Electrique = — — — — Electric. — Puissance à transmettre (en ch.) = power to be transmitted (in HP). — Suède = Sweden. — Danemark = Denmark. — Luxembourg = Luxemburg. — Maroc = Morocco.

In the case of engines of low power, the D. B. and S. N. C. F. consider that a chain drive gives a very simple solution. The speed must be below 40-50 km (24-31 miles)/h. The chain is subjected to less fatigue if it is not used as a means of changing the gear ratio.

In the case of locomotives of average power with 3 or 4 parallel axles, whose speed is restricted, the general recommendation (Sweden, D. B., Luxemburg, S. N. C. B., S. N. C. F., Ö. B. B.) is the jack shaft and coupled rods solution.

In the case of bogie locomotives, driving by cardan shaft and axle drive has been recognised the best solution (D. B., S. N. C. F., Ö. B. B.).

The D. B. mentions conical gears with helicoidal teeth and this is in fact the most usual arrangement. It should be noted that on the S. N. C. F., trials have been made of worm gear axle drives.

15. — *In the case of electric transmission, what arrangements do you advocate to obtain the best adhesion coefficient, from the point of view of :*

a) *electrical connection of the traction motors if the locomotive has independent axles ?*

b) *mechanical connection between the axles in the alternative case ?*

Although the solution of electrical parallel coupling of the traction motors is not as good as mechanical coupling by rods, this solution is the one generally adopted by the Administrations because of its simplicity. This is the case in particular on the N. S., S. N. C. F., Ö. B. B., Tunisia, Addis-Abeba, O. C. F.

On other railways (Sweden, S. N. C. B., Algeria) the engines are coupled in series parallel, at least at the lower speeds. This arrangement assists the wheels slipping and on certain types of locomotives, an anti-slip device has been fitted which slows down the Diesel engine by the differential action between the traction motors coupled in series.

On the N. S., in Sweden, the S. N. C. F. and in Morocco, and for shunting or for secondary line locomotives, the speed of which remains low, the axles are coupled by rods or even by chains (S. N. C. F.).

In the same order of ideas, mention must be made of a device invented by the S. N. C. F. to improve the adhesion. This consists of two 6-wheeled motor trucks, the axles of which are coupled by rods, fitted with two electric traction motors. For shunting and marshalling, these trucks are coupled to the locomotive and the traction motors are inserted in the circuit of the main-generator of the locomotive. In this way, the power is spread over 6 equally loaded axles instead of 3.

* * *

ORGANISATION OF THE SERVICE AND WORKING.

16. — *For which types of locomotives and for what services is driving performed by one or two employees (or more) ?*

Does the second member of the crew have any other duties than those of assisting the driver ?

Only on three Railways (N. S., S. N. C. B., Ö. B. B.) is one man alone used to drive the Diesel locomotives without any restrictions, both for line services and shunting.

On the other Railways, one man is generally used in the case of shunting [1] and two men for line services, with various regulations and exceptions in different countries in the latter case.

Some (Sweden, Denmark) only require an assistant-driver on long distance express trains. Others (D. B.) do without an

[1] With the exception of Algeria, Tunisia, and the D.B. However, these Administrations allow one driver only in the case of simple shunting, or on certain narrow gauge lines.

assistant-driver under certain very restricted service conditions : stopping passenger trains running at less than 90 km (56 miles)/h, or light running with check points every 30 km (18 miles)/h.

Others again (Tunisia) have no assistant driver on certain short distance trains or on assisting locomotives or on their narrow gauge lines (Algeria).

In Luxemburg, there are no assistant drivers on single track lines.

The second man may have other duties to carry out besides helping the driver :

— inspection of the equipment (engine, heating boiler, etc.);

— safety functions :

a) look out on the line;

b) protection of a train when stopped;

c) protection of the second track in case of derailment;

— train service in the case of freight trains;

— accessory duties (cleaning the driving compartment, coupling and uncoupling the locomotive, etc.).

The following table sums up the position on the different Railways in this connection :

17. — *To which department (Motive Power or Operating) do the driving staff belong, according to the type or power of the Diesel locomotive, in the particular instance of shunting, or of station to station light goods traffic services?*

On the whole the drivers form part of the Traction Locomotive Running Department.

However certain Administrations listed below make Traffic Operating personnel responsible for driving certain small locomotives attached to the stations.

18. — *How are Diesel locomotive drivers recruited? How are they trained?*

For most of the Administrations who replied, Diesel traction is taking or will take the place of steam traction. Drivers have therefore been obtained by training « steam » drivers freed by the change-over

However certain Administrations are already recruiting drivers from the shed maintenance staff (S. N. C. F., Algeria, Tunisia, Morocco). In Morocco and on the Ö. B. B. the drivers of low power shunting engines are recruited from the shunting staff.

Training usually consists of a course dealing with the thermal engine and if necessary electricity, and instruction in driving and dealing with breakdowns.

According to the organisation on each railway, these courses and lessons are given either in special centres or in the Diesel locomotive sheds.

19. — *Are your Diesel locomotives in common user?*

In order to ensure the best use of the staff, does your organisation make provision for drivers to be authorised to drive all the different kinds of Diesel locomotives (also if applicable, electric locomotives when the system is partly electrified)?

The Diesel locomotives are generally in common user (banalisées) and the drivers are passed to drive different types of locomotives (and, if necessary, railcars). Most Administrations state that this is advantageous in promoting good user of both locomotives and drivers. On the other hand on the S. N. C. B. like Luxemburg, railcars and Diesel locomotives have drivers allocated to them, and the S. N. C. B. does not systematically allow different Diesel engines to be driven by the same men, and still less electric and Diesel locomotives.

Other Railways however are already doing this, for example Morocco and the S. N. C. F. This latter Administration quotes the example of a Diesel and electric centre where the staff may drive railcars,

Table relating to question 16.

Administration	One man only (line and shunting) without exception	Line		Shunting	
		2 men	2 men or possibly 1 man	2 men or possibly 1 man	1 man
Sweden	......	......	●	......	●
Denmark	......	......	●	......	●
N. S.	●	......	......	......	......
D. B.	......	......	●	●	......
S. N. C. B.	●	......	......	......	......
Luxemburg	......	......	●	......	●
S. N. C. F.	......	●	......	......	●
Ö. B. B.	●	......	......	......	......
F. S.	......	●	......	●	......
Portugal	......	●	......	......	●
Algeria					
standard gauge	......	●	......	●	......
narrow gauge	●	......	......	......	......
Tunisia	......	●	......	●	......
Gafsa	......	●	......	......	●
Morocco	......	●	......	......	●
Addis-Abeba	......	●	......	●	......
O. C. F.	......	●	......	......	●
OTRACO	......	●	......	......	●

Table relating to question 17.

Administration	Maximum power of the shunting engines	Service worked
Sweden	300 HP	Certain special cases
Denmark	167 HP	Shunting and light inter-station services
N. S.	72 HP	Shunting in stations
D. B.	150 HP	Shunting in stations
S. N. C. F.	300 HP	Shunting and light inter-station services
F. S.	150 HP	Shunting in stations
Algeria	100 HP	Shunting and harbour lines

Diesel locomotives or electric locomotives in the same rota.

20. — *Are your Diesel locomotives used both for passenger and freight services? If so, what is gained by this combination of duties?*

All the Administrations consulted replied in the affirmative. It should be noted however that certain Railways are proposing to specialise certain locomotives for hauling fast passenger trains (D. B., S. N. C. F.).

21. — *On secondary lines, do you use the same locomotive for train haulage and for shunting?*

All the Administrations (except Algeria) replied in the affirmative. Although the technical characteristics are different in each case, as a rule it has been found most satisfactory to be able to do the shunting in the station with the train locomotive and also use these locomotives for shunting in the terminus stations after and before using them for the train services. The S. N. C. F. in particular is doing this and has sometimes been able by a suitable re-arrangement of the timetables of the services on the secondary lines, to make use of gaps in the locomotive workings to do the shunting and thereby obtain appreciable locomotive economies (see question 24).

D. B. — Type BB, V 200 locomotive for fast passenger services between large towns. Two 1 000 HP Daimler-Benz, Man or Maybach engines, 4 stroke, supercharged. Voith or Maybach hydraulic drive. Two speed : 140 km (87 miles)/h. Weight per axle : 19 t.

22. — *By what staff is the Diesel locomotive serviced before departure? What are the duties laid down for this servicing?*

The preparation of the locomotive before departure is usually the responsibility of the driver.

On the contrary, this is done by the local staff on the following railways : Sweden, Portugal, Algeria, Addis-Abeba, O. C. F. and OTRACO.

Finally, a few Administrations (Denmark, S. N. C. F.) have it done before departure either by the driver or by local staff, according to the size of the shed and the power of the locomotive.

The time allowed varies obviously from country to country, and from one series to another, 40 min. being an average figure.

23. — *In the case of low power locomotives being in service at isolated districts situated some distance from the home depot and which perform shunting and short distance runs on low density traffic lines, and where driving duties are performed by staff of the stations in that area, how do you organise :*

a) *driving instruction?*

b) *technical supervision of staff in the performance of driving duties?*

c) *inspection and current maintenance of locomotives?*

The Administrations, who replied to this question, have already been mentioned under Question 17. They are : Sweden, N. S., D. B., S. N. C. F., F. S., Algeria. The organisation adopted is common to all types.

Driving instructions and the technical supervision of the Operating staff are the responsibility of the running superintendent of the district concerned.

Daily maintenance is done by the Operating driver. Brief inspections and small repairs are done on the spot by a specialist workman from the neighbouring managing shed.

On the S. N. C. F., when such a system would be profitable, a breakdown service has been organised using a suitably equipped small lorry (tools, spare parts). The workman responsible for attending to the repairs can drive the lorry himself.

Such arrangements result in fewer locomotives having to go back to the depots and being replaced by a spare locomotive. This is only done when a serious accidental repair justifies it.

24. — *Has dieselisation enabled you, because of the inherent capabilities of the Diesel locomotive (self-contained unit, common user, decreased time in preparation and garaging) to modify to any extent the method of operation over certain lines? In the affirmative, have you experienced any difficulty in extending the use of Diesel locomotives beyond the normal daily working period in the case of secondary line operation?*

On the main lines, the replacing of steam locomotives by Diesel locomotives of equal power has not led to any appreciable modifications in the methods of operation.

It is in the working of secondary lines, on the contrary, that the inherent advantages of the Diesel locomotive are able to lead to profound modifications. These advantages have been stressed by Sweden, Denmark, the Ö. B. B. and more particularly by the S. N. C. F.

With a Diesel locomotive in fact it is possible :

— either to use the same locomotive for shunting operations in the station at the beginning of the line and for the train services on the secondary lines by making use of slack periods in the shunting turns (see Question 21);

— or to provide « shuttle » services by turning round at any intermediate station

(owing to the reversibility of the Diesel locomotive);

— or to run longer services in the same staff working period (reduction in the preparation and garaging periods, time taken to water, etc.);

S. N. C. F. — Type BB, 040 DE locomotive for light services on secondary lines and for semi-heavy shunting. One 600 HP 6 cylinder 6 L DA 22 B Sulzer engine, 4 stroke, supercharged. Electric drive through 4 traction motors. Top speed : 80 km (50 miles)/h. Weight per axle : 17 t.

— or to run « circular » services covering the whole day with a change of crew during the run (general user).

Finally, it is possible to base the locomotive on a station where there are no traction department installations.

All these measures are capable of improving the services of a given region.

It should however be pointed out that the desire to make use of the locomotives permanently, over the whole 24 hours, comes up against the difficulty of extending the traffic on these small lines beyond the normal daily working hours. In general, in fact, night services are a disadvantage on the small lines : they do not fit in with the kind of goods carried (milk, cattle) and there is the extra cost of providing keepers at the level crossings. In certain cases, it is however possible to run night services. In other cases, the realisation of such services may lead to a modification in the work of the marshalling yards. Thus the S. N. C. F. have come to the conclusion that the « most economic organisation depends upon what action is

taken in regard to several factors : the extensive user of the Diesel locomotives, the services in the yards and through level crossings, without losing sight of the traffic requirements ».

25. — *Do you consider possible, owing to dieselisation, to improve service and running conditions in passenger and freight traffic?*

Passenger traffic.

The advantages of Diesel traction in this field most commonly recognised are due to the better performance of locomotives of equivalent power to that of the steam locomotives they have replaced.

Thanks to their greater acceleration on the one hand and their reversibility on the other, with the same number of locomotives, Diesel locomotives have made it possible to reduce the journey times (particularly in the case of stopping and semi-direct trains) and increase the number of trains run [1] (Denmark, N. S., D. B., S. N. C. B., Ö. B. B.).

Freight traffic.

In general, the change in the method of traction has not led to improvements in the running of freight trains either on the main lines or the secondary lines.

However, in the case of secondary lines, a trial is in hand on the S. N. C. F., as the following report shows :

« Services worked by Diesel traction can in practice be divided into two categories :

» *a*) a run there and back on a secondary line with little traffic by a Diesel locomotive attached to one of the stations in contact with it where it is used for shunting;

» *b*) services on the lines radiating from a centre or the lines of a section, plus shunting services at one or several centres.

» Within the framework of this second type of dieselisation, the trial of a special method of working is in hand. Here, the timetables for the services and Traffic Department requirements (staff and locomotives) drawn up for the lines of the « section » concerned are merely a general guide. They can be modified according to fluctuations in the traffic or any urgent traffic requirements on the decision of the « head of the section » whose duty it is to regulate each day, in close collaboration with officials of the Operating, Traction and Permanent Way Departments, the circulation of the Diesel locomotives solely according to the current commercial requirements.

» This formula is obviously applicable to secondary lines where the traffic does not necessitate a regular daily service or, on the contrary, on certain days a week, but not on any fixed day, the running of additional trains.

» Owing to its flexibility, this method of working, which is much better than running services on fixed days which is the only thing it is possible to do with steam traction, is much more satisfactory to the railway's clients especially when the fast goods traffic is small and irregular. »

26. — *In what way do you think reserves of Diesel locomotives should be provided to cover such matters as traffic peaks, diversions or emergencies?*

What is the normal use of corresponding engines?

In view of the present position of Diesel traction on the railways, it can be

(1) Certains Administrations, especially outside Europe, have found that the change in the method of traction has gone hand in hand with an increase in the power of the locomotives. These Railways have therefore obtained the opposite result : increase in the loads, decrease in the number of trains. This aspect lies outside the scope of this question.

considered that except in the case of complete dieselisation (Algeria) this method of traction has taken the cream of the traffic in certain sections (train services, or shunting, or secondary lines) and, as is often the case with new stock, the whole of the stock has been put into service. The result is that traffic peaks most often have to be met by « steam » and this method of traction, which has had to give up its throne, before its total extinction, is called upon to play the part of reserve (Denmark, D. B., S. N. C. B., Portugal, Addis - Abeba, Otraco).

Certain Administrations, however (Sweden, N. S., Tunisia) have already taken in the case of Diesel traction the same steps they always take with other methods of traction when dealing with peak traffic : reduction, or even temporary suspension of overhauls and inspections, reinforcements to the sheds with the most work from those with less, etc.

Sweden and the Ö. B. B. state that they have fixed a certain percentage of spare locomotives (5 to 10 %) to cover additional traffic. The S. N. C. F. recalls the theoretical formula fixing the number N of locomotives required, including reserves to cover a given traffic :

$$N = J\ (1 + f + i)$$

in which J is the number of days working required to assure the regular services corresponding to the maximum traffic :

f is an average coefficient corresponding to the optional services;

i an average coefficient of traction stock out of service.

Probably, the railways worked entirely by Diesel traction will have to apply a formula of this sort in the future.

27. — *Even though it may not be general practice, are there any instances where temporary traffic requirements lead to the replacement of railcars or sets hauled by light railcar units by a heavy set hauled by a Diesel locomotive?*

What stock do you consider should be used in such a case : light rolling stock or vehicles previously used in passenger services? Alternatively, do you consider it more economic to intensify the service with railcar units?

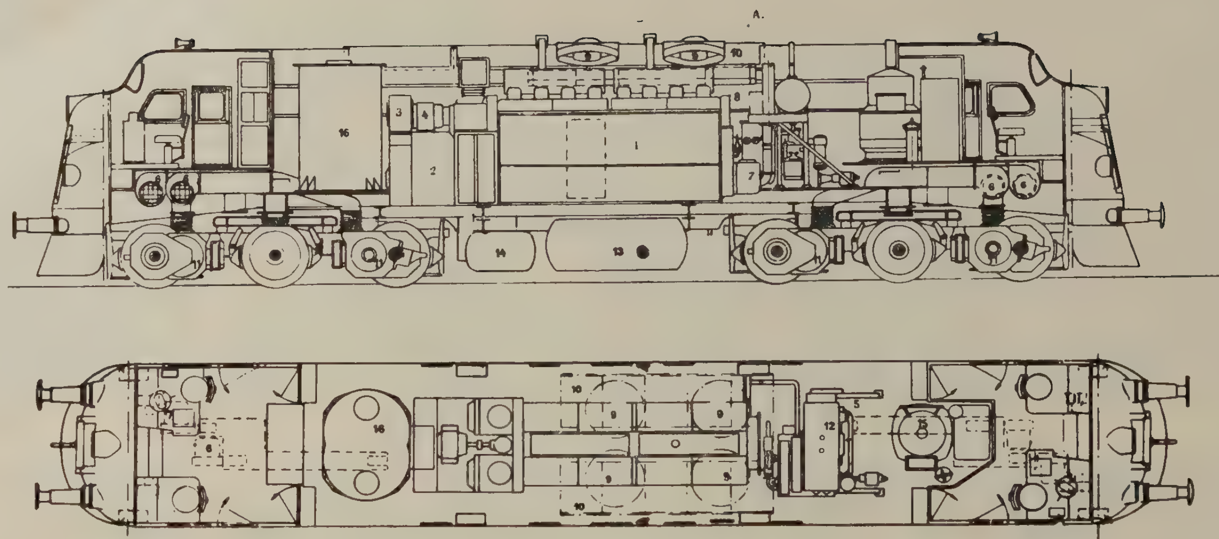
Replies necessarily varied according to the extent of dieselisation on the railway. In countries where Diesel traction is only in its beginnings, there is some advantage in using the old « steam » rakes hauled by « steam » or possibly Diesel locomotives for peak traffic (S. N. C. B., F. S.).

Administrations who have gone further with dieselisation multiply the number of railcar services and multiple or twin units or run a special train hauled by a Diesel locomotive. In Sweden, on the N. S. and the Ö. B. B. this latter solution is definitely preferred. On the S. N. C. F., there seems to be a tendency towards the former solution as the steam rolling stock is being taken out of service.

Then, there arises the problem of reserve stock : additional railcars, additional trailers, light stock for the rake hauled by a Diesel (in Denmark endeavours are being made to use the ordinary coaches for this latter purpose, which have been designed as light as possible). The Administrations who have put into service sufficiently powerful locomotives (S. N. C. B., Ö. B. B.) or locomotives which can be coupled up as multiple units (N. S.) make up trains with the heavy coaches used with other methods of traction.

28. — *What is the proportion of use of Diesel locomotives in service in relation to the effective total stock (for train haulage locomotives and for shunting locomotives)?*

This question gave rise to two different types of answers (it was not possible to give separate figures for the line and shunting locomotives) :



LEGEND.

1. Type 16567 B Diesel engine.
2. Main generator.
3. Turbo-blower.
4. Auxiliary generator.
5. Compressor.
6. Traction motor fans.
7. Lubricating oil filter.
8. Fuel filter.
9. Radiator fans.
10. Radiators.
11. Traction motors.
12. Water tank.
13. Fuel tank.
14. Main reservoir.
15. Heating boiler.
16. Tank for the water for the heating boiler.

Denmark. — Diagram of the type A1A.A1A, MY locomotive intended for fast passenger and freight trains. One 1 700 HP GM engine, 16 cylinders in VEE, 2 stroke. Electric drive through 4 traction motors. Top speed : 133 km (83 miles)/h. Weight per axle : 18 t.

The first group of Administrations gave the average availability of the Diesel locomotives, i.e. the number :

$$\frac{\text{Total number of locomotives in service -Total number of locomotives out of service}}{\text{Total of locomotives in service}} \times 100$$

The numbers quoted lie around the value 80 (Portugal : 75; Otraco : 78; Luxemburg : 80; N. S. : 80; Addis-Abeba : 83; D. B. : 83; S. N. C. F. : 87).

A second group of Administrations gave the actual average user, taking into account and locomotives damaged, and the utilisation of the locomotives in service, i.e. the number over a given period.

$$\frac{\text{Actual number of hours in service}}{\text{Number of hours clocked by the locomotive stock}} \times 100$$

These numbers have an average value of 50 (Algeria : 47; Tunisia : 50; Gafsa : 53) with a minimum value of 37 (Morocco).

These results lead to two general conclusions :

— out of 5 Diesel locomotives, 1 will be out of service and 4 in service;

— each Diesel locomotive of the stock will work 12 h out of 24 [1].

29. — *What changes have occurred, in relation to steam traction, the average kilometric distances covered by the locomotives (compared with the total stock) by kind of service?*

Where you have had occasion completely to substitute Diesel for steam traction in a large shunting yard, what was the required number of steam locomotives, what is the number of Diesel locomotives with which you have been able to maintain the same service?

It was a question of finding out, for each kind of service, how many steam locomotives the stock of Diesel locomotives had replaced, under equal service conditions.

In general, the Administrations were not able to give any details for each kind of service, either because of a lack of statistics, or because important changes in the traffic made it impossible to make any comparisons.

We had therefore, to give an overall number per Administration. *(See table hereafter.)* This number represents the fraction :

$$\frac{\text{Number of steam locomotives}}{\text{Number of Diesel locomotives,}}$$

the calculation being based on an equal service being worked (line and shunting, availability and out of service included) before and after dieselisation (of a railway, a section, a line or a given shunting yard) [1].

It is quite normal for the resulting products to be very different due to the different conditions. It can however be stated :

— that Railways ouside Europe gave very high values, dieselisation having resulted in a complete reorganisation of the service and the suppression of ancient methods and installations of very low efficiency;

(1) It should be noted that the European Railways gave no information in this connection.

(1) Sometimes the figures given were based on a preliminary study and have not been proved by experience.

Administrations	Equivalent ratio	Comparison covering
Sweden	1.5	An important maritime station.
Denmark	1.5	10 Diesel locomotives.
N. S.	1.3	The whole railway : line services. Comparison between the average runs of steam locomotives still in service and the average runs of the diesel locomotives, some of which have only recently been delivered. (June 1955).
D. B.	1.14 1.3	Study of dieselisation on the Schleswig-Holstein line, 116 locomotives, shunting engines and railcars. Study of dieselisation for freight services on the right bank of the Rhine. 58 Diesel locomotives.
S. N. C. B.	1.7	Study of dieselisation of freight service on the Athus-Meuse line.
Luxemburg	1	Heavy shunting.
S. N. C. F.	1.3	Important marshalling yards.
Ö. B. B.	1.3	20 diesel locomotives.
Tunisia	3.2	The whole of the diesel stock.
Gafsa	2.7	17 diesel locomotives.
Morocco	3 1.25	18 Diesel locomotives. Casablanca shunting yards.
Addis-Abeba	1.6	Whole of the diesel stock.

NOTA. — In the case of shunting, the figures relate to an equal number of hours of shunting. It should however be noted here that the work done by a diesel locomotive in one hour is more productive than that done by a steam locomotive of equal power. This is due to the utilisation of the whole of the admissible tractive effort from the time of starting up, to the great acceleration which results, to the quickness with which it can reverse all of which advantages can be summed up in fact by a greater number of wagons shunted per hour.

On the Morocco Railways, it is stated that they have « been able since the dieselisation of the shunting yards of Casablanca to work the same number of hours at shunting although the number of wagons, shunted has increased by nearly 50 % ».

This superiority of the diesel locomotive, in conjunction with its high rate of availability and its complete self-containedness (as well as the purely economic advantages atached to it which will be dealt with under question 43) have made it of particular value for shunting work.

— that in Europe the ratio appears to lie between 1.2 and 1.7 before any thorough study of the conditions of the problem raised by dieselisation.

* * *

MAINTENANCE.

30. — *What factor do you take as a basis for determining the frequency of inspections and periodic overhauls of Diesel locomotives? Is the basis of*

examination carried out on mileage, number of running hours, number of operating days, etc.?

State the reasons for your preference.

In particular, in connection with Diesel engine maintenance, do you consider that it is preferable to relate the examination to the characteristics of the engine itself and base it on such factors as: oil analysis, spectrographic examination of oil, rate of compression, unit consumption of oil, etc.)?

On this question, very different opinions were put forward by the Administrations. Their replies can be classified as follows:

Maintenance periods depending solely upon the mileage.

On certain railways, the intervals between periodical inspections and overhauls (we deal with the work done in question 31) are determined solely by the mileage done by the locomotive. This is the case in particular on the Ö. B. B. and Addis-Abeba Railways. To simplify checking the mileage done, on the Addis-Abeba Railway certain locomotives have been equipped with a trip and total mileage indicator.

In Sweden and Denmark, the overhauls to line locomotives depend on the mileage worked, and that of the shunting engines on the number of hours work. This number of hours is converted to kilometres according to a predetermined rate (10 km to the hour in Denmark), which amounts to basing all the overhauls on the mileage worked.

In the case of their line locomotives only, the following Administrations have adopted the mileage as a basis: S. N. C. B., F. S., Gafsa, O. C. F., Otraco. Some of these Administrations agree that the mileage parameter is not always the greatest indication of the amount of wear. In the case of the engine, for example, a few hours of running slow in bad temperature conditions may cause a lot more wear than 1 000 km under normal conditions. Nevertheless, as the services are usually approximately the same, it was considered that the mileage was a sufficiently sure guide for all the various components taken as a whole, and had the advantages of being easy to follow.

Overhauls based on the number of hours worked.

This is the case with the shunting engines of the S. N. C. B., Luxemburg, F. S., Gafsa and Otraco. On the last two railways, the engines are fitted with indicators showing the total number of hours worked.

Overhauls based on time intervals.

This is the rule in the case of inspection only (overhauls are still based on the mileage) on the North African Railways (Algeria, Tunisia, Morocco) [1], and is also the formula to which the S. N. C. F. is gravitating.

There is no doubt but that in determining the inspection programmes for the depots, the spacing of the inspections according to the number of days in service greatly facilitates the maintenance services. On the S. N. C. F., however, they try not to deviate too widely from the rule (« mileage » and the programmes drawn up are controlled and if necessary modified according to the average daily mileage.

On the D. B., the N. S., and in Portugal, both inspection and overhauls are based on the time parameter. On the D. B., for example, there are periodic inspections at « weekly » intervals (though the « week » has now been increased to 12 days), monthly, quarterly and yearly intervals. The engine is over-

[1] In the case of Tunisia, the time factor is only used in order to fix the maximum intervals between inspections, which are based in principle upon the mileage.

hauled every three years. There is a general overhaul every 5 years.

On the N. S., inspections and overhauls are in principle as follows : A inspection every 3 to 4 weeks, B inspections every quarter, C inspections every year. General overhaul every 4 years; complete overhaul every 8 years. Care has been taken to make sure that these intervals correspond to the wear of the Diesel engine and the locomotive by following the actual consumption of fuel oil in the case of shunting engines and number of hours in service of line locomotives.

Examination of the indices.

(Analysis of the oils, compression pressure, fuel consumption, etc.).

Several Railways make a systematic examination of these indices (N. S., D. B., S. N. C. B., Luxemburg, S. N. C. F., Portugal, Addis-Abeba, Otraco).

An examination of the lubricating oils (from the rudimentary examination on the job down to laboratory tests) shows the state of cleanliness of the oil, which prevents premature wear (or causes it) and also may give information about some defect which otherwise would not be discovered till later (a break in the fuel pipe line, cracks in the linings, etc.). In Portugal, and recently on the S.N.C.F., a spectographical examination is made of the ashes which appears to offer great possibilities.

The examination of the compression pressure, and the checking of the oil consumption give warning of possible loss of power in the Diesel engine.

In no case, however, are such examinations used to determine the maintenance intervals. These methods must rather be considered as intended to keep a close check on the condition of the Diesel engine and by the information they give assist in obtaining a preventative and rational maintenance policy.

31. — *What is the type and frequency of inspections and periodic overhauls that you have adopted?*

Table III shows some of the repair cycles given as examples by the Administrations who make use of the mileage to determine the intervals between inspections and overhauls. Comparable works have been named and marked in an identical way, without taking into account the appellations used by the different Railways. Approximations have also been made, and the indications which follow regarding the kind of check-up are naturally only an average.

Minor overhauls
(between 0 and 10 000 km [0 to 6 200 miles]).

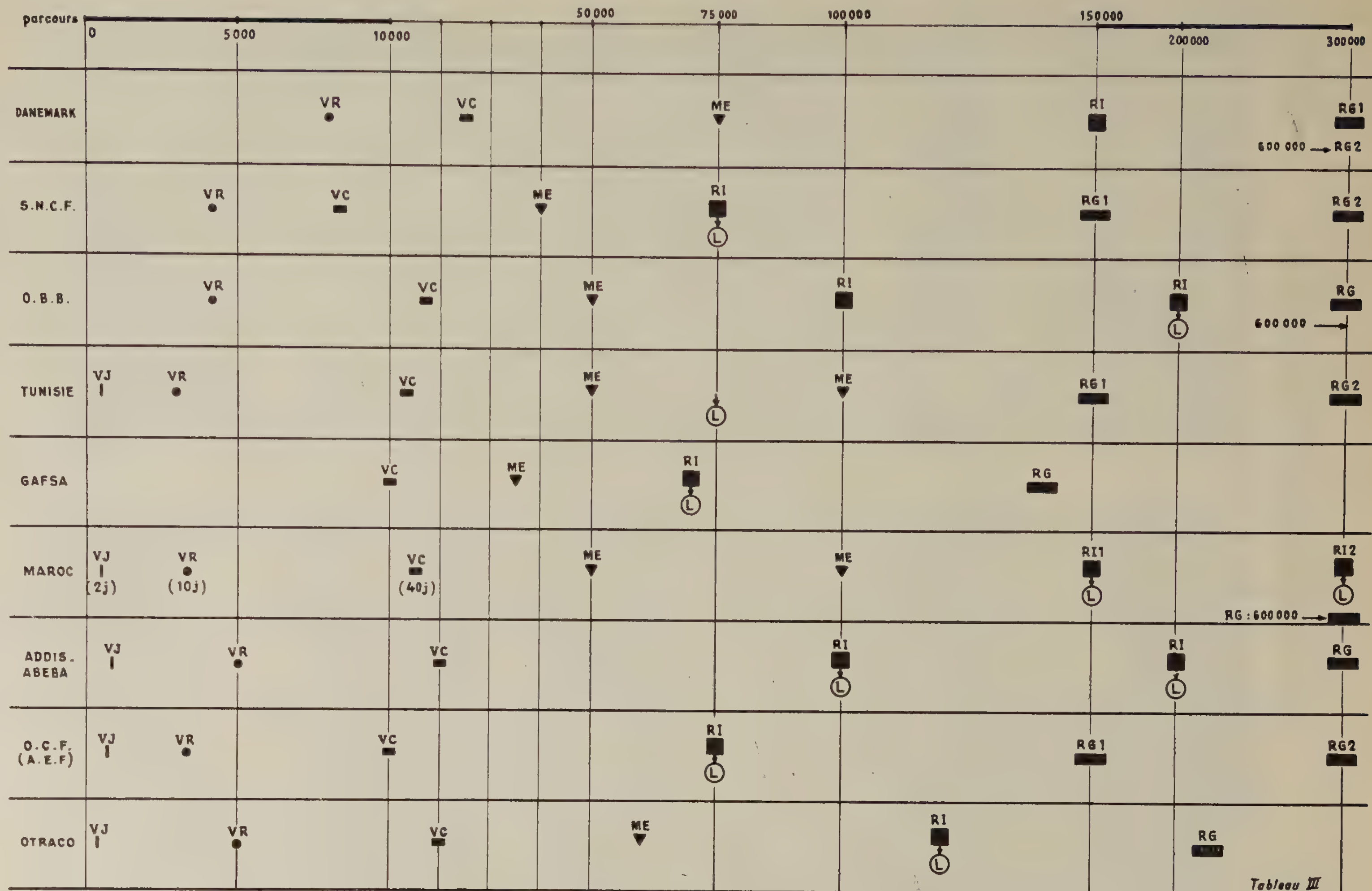
The *daily inspection* (VJ) is the most summary check-up. Certain Africain Railways make a check-up whenever the locomotive goes back to the terminal depot. It is in fact *an inspection* by a more experienced driver, passed by specialised staff as proficient.

The *general inspection* (VR) is the basic inspection. It is carried out between 3 000 and 5 000 km (1 820 and 3 100 miles). It includes in principles:
— a brief inspection of the various equipment;
— cleaning and if necessary replacing the filters;
— checking the condition of the oil;
— lubricating certain components;
— checking the brake gear.

On the S. N. C. F., it is accompanied by a check of the working of the fuel injectors, either on the bench or on the locomotive by means of a compressiometer.

The *complete inspection* (VC) is a more thorough and extended VR inspection in principle it is during this inspection that the injectors are calibrated, and it also includes:
— checking and adjusting the play of the valve rockers;

TABLE III.
INTERVALS BETWEEN INSPECTIONS AND OVERHAULS.



Explanation of French terms:

Parcours = mileage. — Danemark = Denmark. — Tunisie = Tunisia. — Maroc = Morocco.

— blowing and testing of load of the electrical equipment;

— opening the inspection doors of the engine casing, exterior inspection of the rods, pistons, rings, measuring the play of the bearings;

— inspection of the running-gear.

Minor overhaul

(40 to 60 000 km [25 to 37 000 miles]).

The work done during the *minor overhaul* (ME) in addition to that included in the complete inspection consists of:

— the check-up and the tightness of the piston rings and valves with descaling;

— complete check-up of the brake gear;

— complete check-up of the electrical equipment;

— sometimes a check-up of the crankshaft line.

On the whole, the work done during slight and minor overhauls does not differ greatly from one Railway to another. As will be seen it is only as regards the general overhaul (taking out and overhauling the engine) that policies are widely divergent.

Nota. — In the case of those Administrations who base the intervals between inspections on the time factor, the *fortnightly* inspection corresponds to the general inspection (VR), the *monthly* ins--pection corresponds to the complete inspection (VC) while the *quarterly* or half-yearly inspection corresponds to the minor overhaul (ME). The kind of work done is more or less the same in both cases.

Complete overhaul.

The *intermediate overhaul* (RI) is the operation during which the Diesel engine is partly overhauled, though it is left in place on the locomotive; it is opened up and the liners, rods and pistons are repaired or exchanged. Play and bores are checked. The auxiliaries are also repaired or exchanged (pumps, turbo-blowers, regulators).

During the .RI the body is usually lifted so that the wheels can be reprofiled and the mechanical parts overhauled. When possible, standard exchanges of components take place, of the bogies for example.

The mileage after which RI takes place varies from 75 000 km (46 000 miles) (S. N. C. F.) to 150 000 km (93 000 miles) (Denmark, Morocco) i.e. from one to double. There is therefore very considerable variation.

The *general overhaul* (RG) is the most complete overhaul. This is always carried out in a special depot, the whole locomotive being stripped down. Certain Administrations have two types of RG, the RG_1 and the RG_2 which differ according to the amount of work carried out.

The mileage after which the general overhaul takes place varies from 150 000 km (93 000 miles) (S. N. C. F.) to 300 000 km (186 000 miles) (Denmark) or even 600 000 (372 000 miles) (Morocco).

Here again there seems to be considerable differences of opinion.

It must be pointed out however that this question of the mileage is very much in a state of evolution. Quite apart from the fact that the results which we have reported are very fragmentary, if only because each Administration has chosen very different mileages for each series of locomotives, it should also be noted that there is a tendency to increasing the length of the cycles on all the Railways.

When the locomotives are first put into service, each Administration follows the advice given by the builders. The mileages and intervals adopted to begin with are soon seen to be the minima according to the terms of the builder's guarantee. From their own experience, and taking into account the improve-

ments made to the most delicate parts, the Railways though proceeding with caution soon find that they can reduce the number of inspections and it appears that the most economical maintenance policy is to carry out repairs to a high standard of work at long intervals.

32. — *For engine cooling, do you use :*

— plain water or water that has been treated, i.e. anti-freeze ?

— pure distilled water ?

— water to which a chemical has been added with the object of avoiding corrosion to the jackets and to the Diesel units.

Ordinary water is used in Sweden and on the Ö. B. B., as well as by the Otraco for shunting engines.

In other cases (except in Addis-Abeba where pure distilled water is used), an anti-corrosive is added to distilled water. This product is usually potassium or sodium bichromate. Unfortunately, anti-freeze solutions cannot be used with bichromate, which is a great drawback in cold countries. On the D. B. « soda hexametaphosphate » is used.

Certain Administrations (chiefly in countries where distilled water is not used or where the water is particularly hard) soften the water before using the bichromate treatment (S. N. C.B., Luxemburg, Algeria, Tunisia, Morocco).

33. — *What are the average percentages out of service due to :*

— inspections;

— overhauls;

— accidental causes.

The replies received from the Administrations are summed up in the following table :

<table>
<tr><th rowspan="2">Administrations</th><th colspan="4">Percentage of time out of service</th></tr>
<tr><th>Inspection</th><th>Overhauls</th><th>Accidents</th><th>TOTAL</th></tr>
<tr><td>Sweden</td><td>6.5</td><td>6.5</td><td>—</td><td>—</td></tr>
<tr><td>N. S.</td><td>5</td><td>5</td><td>3</td><td>13</td></tr>
<tr><td>D. B.</td><td colspan="2">10</td><td>6</td><td>16</td></tr>
<tr><td>Luxemburg</td><td colspan="2">10</td><td>10</td><td>20</td></tr>
<tr><td>S. N. C. F.</td><td>3.5</td><td>4.5</td><td>4.8</td><td>12.8</td></tr>
<tr><td>Ö. B. B.</td><td>—</td><td>—</td><td>—</td><td>20</td></tr>
<tr><td>F. S.</td><td colspan="2">15</td><td>5</td><td>20</td></tr>
<tr><td>Portugal</td><td>5.2</td><td>12.9</td><td>5.3</td><td>23.4</td></tr>
<tr><td>Algeria</td><td>6</td><td>5</td><td>3.5</td><td>14.5</td></tr>
<tr><td>Tunisia</td><td>21.9</td><td>3.3</td><td>3.9</td><td>29.1</td></tr>
<tr><td>Gafsa</td><td colspan="2">20</td><td>1</td><td>21</td></tr>
<tr><td>Morocco</td><td>5</td><td>3.5</td><td>2</td><td>10.5</td></tr>
<tr><td>Addis-Abeba</td><td colspan="2">16</td><td>2.5</td><td>18.5</td></tr>
<tr><td>O. C. F. (A. E. F.)</td><td colspan="2">20</td><td>5</td><td>25</td></tr>
</table>

INSTALLATIONS.

34. — *Do you consider that the installations made available by the withdrawal of steam traction are sufficient after some alterations ? In the affirmative, what are these alterations concerning in particular :*

— the scores (fuel, lubricating oil, water, sand, etc.);

— the inspection;

— the repair of Diesel locomotives.

Except in a few countries (N. S., Tunisia, Addis-Abeba, Otraco) where it was desired, when introducing dieselisation to centralise the traction installations, the Administrations considered that the existing « steam » depots could be used for Diesel traction after a few modifications or rearrangements. The main points which should receive attention in such a case are listed below, as stressed by various Administrations.

First of all it is a good thing, if only for safety reasons, in depots where « steam » locomotives are also dealt with, to separate the tracks and installations used by the Diesel locomotives. This may perhaps involve a change in the sidings so that one or several reception and departure sidings can be reserved for the Diesel locomotives. In this connection, it should be noted that the turntables or transhipping gear may have to be enlarged, in view of the length of certain railcars.

In the actual shops, it is also a good thing to reserve one or several sidings, or part of the roundhouse for the maintenance of Diesel locomotives and to enclose this portion (protection against dust, less risk of fire, possibility of heating the section).

On the outside, on the entry and exit sidings, it is desirable to provide :

— fairly deep inspection pits;

— fuel tanks for storing and filling up with Diesel oil;

— watering places, either treated or not, to fill up the radiators and take in water to fill the tanks for the train heating plant;

— places for taking sand (usually gravity fed).

In the shops, the most complete installations will include :

— raised platforms to make it possible to work on the level of the locomotive running boards;

— pits at the sides to facilitate taking down and reassembling;

— deep centre pits, as the dimensions of Diesel components are usually greater than those of steam locomotives;

— sufficient space between sidings for the same reason;

— sufficiently strong lifting gear, in view of the weight of the components;

— special circuits for supplying under pressure the various oils, compressed air, distilled water, fuel oil, cooling water, sand and for removing the old oil;

— hoods or special devices (see question 37) to take away the exhaust gases;

— a zone in which the parts taken down can be washed and rinsed.

As far as the shop portion of the depot is concerned, it may be found necessary, if the work carried out at this depot justified it, to set aside certain small specialised shops to deal with the injectors and fuel pumps, repairing the small electrical gear, etc. It may also be necessary, though usually only in the case of the large shops, to buy special machine-tools (machine to truing up the crankshafts for example).

Naturally, each Administration, according to the end in view and the equipment available, has realised all or part of the arrangements enumerated above, according to the infinite variety possible in converting existing establishments.

35. — *What arrangements have you adopted in your installations for storing and distributing large quantities of Diesel oil, size of stores in relation to daily consumption, handling methods, purification process, system of distribution?*

All the Administrations have decided to stock fuel-oil at the consuming centres in two or more tanks, in view of the fact that emergency refuelling at the stations, when unavoidable, can be done with 200 l (44 gallons) barrels. This latter method of operating is always avoided as much as possible.

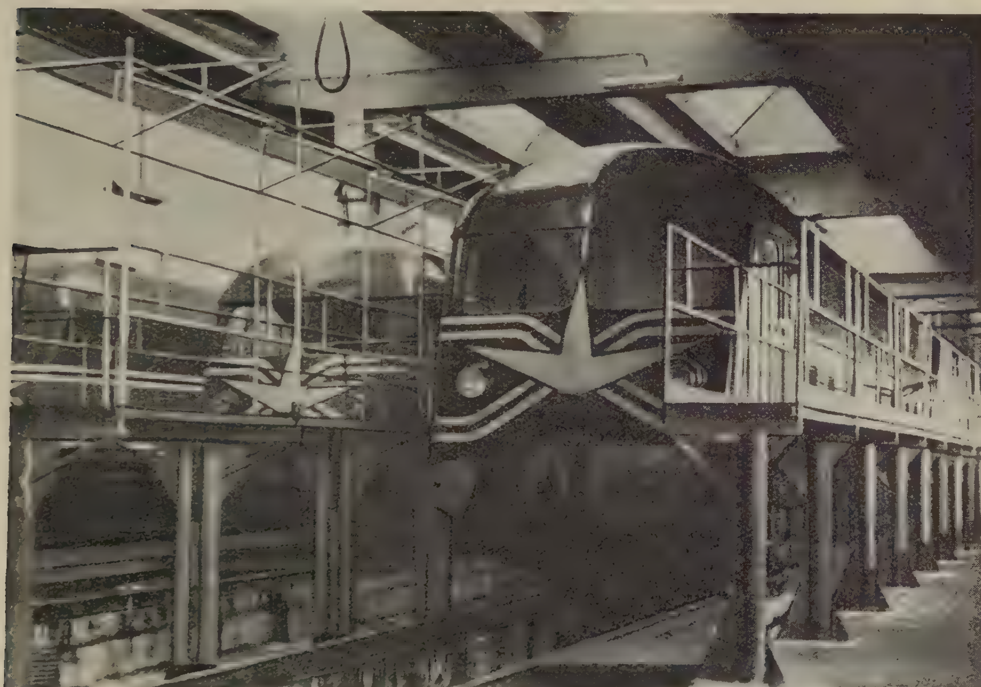
When one tank is being emptied, the other or others are settling. The capacity of the tanks naturally depends on requirements. The factors that have to be taken into account are:

— average and maximum daily consumption;

— provision of sufficient reserve of fuel; the distance of the consuming centre from the international distribution centres has also to be taken into account in some cases (certain colonial countries);

— possibility of discharging the full load of a tank wagon at once (usually 30 m³ = 30 cubic yards).

In fact the total capacity of a fuelling centre varies from 13 days (Algeria) to 60 days (D. B.) of average daily consumption, the usual numbers being between 20 and 40 days. The settling periods vary between a minimum of 7 days (Morocco) to 30 days (D. B.), the most usual period being about 10 days.



S. N. C. B. — Type BB, series 201, locomotive at Kinkempois Diesel shed. One Cockerill engine (Baldwin licence), 4 stroke, supercharged. Electric drive. Top speed: 120 km (74 miles)/h. Weight per axle: 22 t. Note the arrangement of the shed: side pits, inspection gangways.

The oil is generally filtered before (rough filtering) and after settling (fine filter on the distribution pipe line). Sometimes, to avoid the use of filters on the distribution circuits, use is made of a tank holding at least a day's supply of purified and filtered fuel oil (mentioned by the S. N. C. F.).

Certain Administrations still centrifuge their fuel oil (Algeria, Tunisia, Gafsa, O C. F., Otraco). It appears that this practice has now been given up in Europe where everything possible is done to improve the filtration at distribution.

A trial of static water separators and filters to remove particles the size of a micron is in hand on the S. N. C. F.

The oil is generally supplied by service station type pumps with gallon indicators.

S. N. C. B. — Service station at Kinkempois Shed. The pipes supplying fuel oil and water for the heating boiler of the train can be seen as well as the meters and supply pump filters.

36. — *Do you consider it necessary to provide cover for Diesel locomotives and to heat sheds provided for their protection?*

What method do you use?

In European countries with severe winters, it is considered desirable to shelter the locomotives, either during inspections or when they are garaged. However, no Administration has found it possible to build covered sheds everywhere where Diesel locomotives are used. The difficulty has been solved in two different ways:

— either the locomotive is equipped with devices to keep up the temperature of the cooling water during stops (coal or coke heaters on the Ö. B. B., boiler or electric equipment in Sweden, lagged hot water tank on the S. N. C. F.);

— or, and this is only possible in the case of shunting engines, the engines are kept working continuously, and the engines left running during periods of idleness which could not be avoided.

When there are sheds available, the usual methods of heating by means of stoves, radiators or even hot air, may prove uneconomical. On the Ö. B. B., hot air is then blown under the vehicles through the inspection pits, from a heating unit. This is also under consideration on the S. N. C. B.

37. — *What arrangements do you think should be introduced into workshops and sheds for the dispersal of exhaust gas?*

Various methods of evacuating the exhaust gases have been mentioned:

— hoods with natural ventilation, but the draught may prove insufficient: the gases have a tendency to fall back. On the D. B. use is made of hot air heating installations to blow hot air through the pits and thus renew the air in the pits where the heavy exhaust gases tend to accumulate;

— forced ventilation hoods, which have the drawback of creating a serious draught in winter: it then becomes difficult and expensive to heat the place;

— movable chimneys (Denmark, S. N.-C. B., S. N. C. F., Ö. B. B.) which catch the gases as close as possible to the exhaust of the locomotive. Such chimneys may be fitted with fans or not.

* * *

INQUIRY INTO SAVINGS TO BE MADE.

38. — *What are the reasons which lead you to substitute Diesel traction for steam traction?*

Amongst these reasons, which are those of essentially economic consideration?

The administrations who saw that the renewal of part of their stock of steam locomotives would be necessary in the more or less near future naturally embarked upon changing the method of traction which would result in savings in the cost per kilometre. For many of them, their experience with railcars, the first stock to be used with Diesel traction, had already shown them — and operating by means of Diesel locomotives will confirm it — the cost headings under which Diesel traction is definitely more advantageous than steam traction.

These headings are:

— fuel;

— driving;

— the running of the depots.

Under the heading « maintenance », savings, as will be seen, are less marked.

The savings estimated by each railway as due to traction by Diesel locomotives will be given later on in this report (question 43).

All the Administrations as a whole have been convinced that for various reasons Diesel traction is more economical than steam traction, especially for

shunting. It must also be added that in certain countries the field of application of Diesel traction depends upon the policy as regards electrification.

In the replies the Administrations have reported the reasons, other than purely economical ones, which led them to embark upon dieselisation. Amongst these are :

— clients requirements in the case of the passenger services (comfort, speed, cleanliness);

— social considerations as regards working conditions for drivers and maintenance men;

— special considerations, such as water or coal supplies for steam locomotives; which have always been a serious problem in colonial countries;

— purely technical reasons, such as flexibility of working or the greater ease of running services on lines with steep gradients or difficult tunnels.

All these considerations are summed up in the following table : the reason « modernisation of the stock » has been taken as the *a priori* cause of dieselisation. This has been put before economic reasons.

Administration	Modernisation of the stock	Economic reasons			Other reasons			
		Saving of fuel	Saving of engine drivers	Savings in maintenance costs	Improved services	Improved working conditions	Solving the water and coal problem	Facility of operating
Sweden	......	●	●	......	......	......	......	......
Denmark	......	●	●	......	●	●	......	●
N. S.	......	●	●	......	......	......	......	●
D. B.	●	......	......	......	●	......	......	●
S. N. C. B.	......	●	●	......	●	......	......	......
Luxemburg	......	●	●	●	......	......	......	●
S. N. C. F.	●	●	●	......	●	......	......	......
Ö. B. B.	......	●	●	......	......	......	......	......
F. S.	●	●	●	●	●	......	......	●
Portugal	●	●	......	......	......	......	......	......
Algeria	●	●	......	......	......	......	......	......
Tunisia	●	●	●	●	......	......	●	●
Gafsa	●	●	......	●	●	......	●	......
Morocco	......	●	......	......	●	......	●	......
Addis-Abeba	......	●	......	●	......	●	●	●
O. C. F.	●	●	......	●	......	......	●	......
OTRACO	......	●	......	......	......	......	......	......

39. — *Has the substitution of Diesel for steam traction resulted in extra expenses? economies that you did not foresee? Has the changeover given all the economies expected?*

From the replies received it appears that two general considerations can be put forward :

— the maintenance of Diesel locomotives involves stocking a larger number of spare parts than with steam locomotives. The materials and parts

involved usually require better tools and greater precision in machining than is possible in the maintenance centres which then are merely used for standard exchanges, the repairs being carried out in special shops. The result is that where studies have been based upon the capital invested in spares for steam traction to determine those required in the case of Diesel traction, experience has shown that it is necessary to allow supplementary sums to increase the stock of spares;

— generally, the economies expected have been obtained in practice. However, the economies obtained have been less than those expected where dieselisation has only been partial and where in consequence the installations proper to steam traction could not be completely suppressed.

40. — *Has dieselisation, by enabling you to offer better services, increased receipts because of improvements in the quality of the service? Can you give a percentage indication of this increase in receipts?*

The relatively recent experience of Diesel traction on the one hand, and the lack of accurate statistics on the other, have made it impossible for certain Administrations to give a definite reply. Certain Administrations (Sweden, N. S., S. N. C. F., Ö. B. B., Portugal) agree in thinking that railcars and fast Diesel rakes have brought back passengers to the railway or at least prevented more of them from giving it up. These advantages cannot be expressed in figures.

In the case of freight traffic, in general Diesel traction has not been able to effect improvements in the quality of the service and has not led to any new receipts (see question 25).

41. — *Does it appear to you that the substitution of Diesel for steam traction is likely to lead to economy in track maintenance?*

The variation in permanent way maintenance costs in terms of the characteristics of the locomotives depends on a great many factors (axle loads, diameter of wheels, rigidity of the frame, etc.). The changeover from steam to Diesel traction involves changes in these factors the consequences of which are either good or bad. The Administrations state that on the whole they are not able to decide whether dieselisation will make it possible to effect any savings in the maintenance of the track and they have not yet prepared any valid comparisons.

In this connection, it should be noted that the powerful Diesel locomotives have sometimes been found to be harder on the permanent way than the steam locomotives which they have replaced (cf. a note by Mr. J. W. DIFFENDERFER which appeared in the May 1955 issue of the *Congress Bulletin*) because of:

— their considerably higher axle loads;

— the greater thrust they exert on curves owing to their smaller wheels;

— the « crablike » position taken up by the bogies and trucks on the track;

— their greater acceleration in places where formerly the speed was much lower (gradients, entering and leaving curves, near stations).

On the other hand, Diesel traction can definitely be credited with two advantages:

— less risk of fire along the track (estimated at 80 or even 100 %);

— saving in cleaning the ballast.

We might add that certain Administrations have been able to make economies in the water supply (which belongs to a certain extent to the Permanent Way Department) where steam traction has been completely suppressed and where other requirements have not made it necessary to retain the water supply installations.

42. — *Based on equality of service within a district, what is the percentage estimate of economies in staff in the internal departments of depots (apart from actual maintenance)?*

The Administrations have noted on the whole a very considerable reduction in labour costs after conversion to this method of traction. Such a conversion involves in effect:

— doing away with the removal of cinders and ashes, sweeping the smoke tubes, lighting and looking after locomotive fires;

— a reduction in the time spent in handling fuel and moving the locomotives.

The percentages of savings mentioned by each Administration have been included in the table given for the next question in order to simplify the report.

43. — *In the substitution of Diesel for steam traction, what is your percentage estimate of resultant economies:*

— for train haulage service?

— for shunting services?

and for each of the following:

— fuel (calculation to be made with and without special motor fuel taxes payable by the railway);

— locomotive crews;

— maintenance and repair of rolling stock (labour and materials separately).

To make the comparison, it was recommended to adopt for the two methods of traction:

— for the line services, the same number of gross tons kilometres hauled;

— for the shunting services, the same number of wagons shunted.

The values mentioned in the replies are given in the following Table:

The following general conclusions can be deduced from this table:

— the savings obtained under each heading are greatly affected by the amount of taxation on the fuel oil;

It appears that without taxes, the savings would be of the order of 60 % in the case of line services and 75 % in the case of shunting services. The taxes often reduce these savings very considerably;

— as regards drivers, the savings amount to 25 to 35 % for all the services. On the Ö. B. B. where only one driver is used, they exceed 50 %;

— if savings are generally listed under the heading maintenance, this point of view is not absolutely general. We agree that probably on the whole there is some savings, but only small ones;

— substantial savings, varying from 30 to 60 % can be obtained in connection with the service personnel at the sheds.

44. — *When Diesel traction is substituted to steam traction what is the percentage of the estimated economies, under the same conditions as those in Question 42, relating to the reduction of the installations in depots?*

The Administrations do not consider they have acquired sufficient experience to make any statement on this question.

45. — *Has the substitution of Diesel for steam traction resulted in economies other than those shown above?*

No other savings have been mentioned other than those already dealt with.

46. — *Can you give a concrete example of the complete economic financial results for the substitution of Diesel for steam traction on a line or a group of lines belonging to your Administration?*

Certain Administrations sent in studies regarding the replacement of steam trac-

Traction Department Savings in percentages

Administrations	Fuel		Driving	Maintenance		Service in the sheds
	with taxes	without taxes		labour	materials	
Line services						
Sweden	—	50	55	—	—	50
Denmark	—	60	52	—	—	—
D. B.	near 0	—	—	—	—	40
S. N. C. F.	29	69	25	6	6	60
Ö. B. B.	40	—	55	30		45
Algeria	35	60	35	15	15	25
Tunisia	—	60	36	64	60	22
Gafsa	47	74	29	51		50
Morocco	—	70	25	10	+ 100 (1)	60
Addis-Abeba	—	86	25	65	57	—
O. C. F. (A. E. F.)	—	74	29	47	3	70
Shunting services						
Sweden	—	80	55	—	—	
D. B.	45	—	—	—	—	
S. N. C. F.	45	75	35	22	0	
F. S.	—	82	42	20	+ 5 (1)	
Algeria	55	75	30	15	10	
O. C. F. (A. E. F.)	—	71	50	—	—	

(1) All the numbers quoted in this table represent a reduction in the costs with the exception of those preceded by a plus sign which represent an increase, expressed as a percentage.

tion by Diesel traction. We will quote the conclusions of two of these studies dealing with the dieselisation of freight services. The lines in question are the Athus-Meuse line of the S. N. C. B. and the group of D. B. lines: Wedau-Gremberg, Mainz-Bischofsheim (right bank of the Rhine).

1) *Athus-Meuse line :*

Length of line	75 km (46.6 miles)
Diesel locomotives concerned	49 BB and CC locomotives of 1 700 HP to replace 85 steam locomotives.
Capital invested	490 million Belgian francs (including spare parts and rearrangement of the sheds).
Service	2 700 000 train-km per annum; 2 800 000 thousand gross t/km per annum.

Operating savings	75.7 million Belgian francs, i.e. as a percentage of the capital invested : $\frac{75.7}{490} = 15.5\ \%$; or as a percentage of running costs with steam traction : *40.3 %*.
Total saving with sinking fund and interest charges (1)	80.8 million Belgian francs; or as a percentage of the capital invested : $\frac{80.8}{490} = 16.5\ \%$; or as a percentage of the running costs with steam traction : *36.2 %*.

2) *Right bank of the Rhine :*

Length of lines	190 km (118 miles).
Proposed Diesel locomotives	58 locomotives of 1 800 HP to replace 75 steam locomotives.
Capital investment	49.3 million D.M.
Services	7 900 000 train-km per annum; 7 480 000 thousand gross t-km per annum.
Operating economies	3.25 million D.M. i.e. as a percentage of the capital invested: $\frac{3.25}{49.3} = 6.6\ \%$; or as a percentage of the operating costs with steam traction : *14.7 %*.
Total saving with sinking fund and interest charges (1)	2.1 million D.M.; or a percentage of capital invested : $\frac{2.1}{49.3} = 4.3\ \%$; or a percentage of operating costs with steam traction : *8.8 %*.

We must make it clear that these results are merely estimates; they have not the sanction of experience, no Administration being as yet in a position to give a complete balance sheet obtained from actual costs and savings realised.

In brief, it can be stated that Diesel traction, although approaching maturity from the technical point of view, is at present in such a stage of development that no precise figures can be produced as yet about the complete economic consequences of the changeover. It will only be in a few years time that precise conclusions can be formulated when the multiple aspects of the problem have had more light thrown upon them.

* * *

(1) Rate of interest : 5 %. Expectation of life : 35 years, for both steam and Diesel locomotives.

CONCLUSIONS.

1. The formula which consists of having all the power on one single locomotive is suitable in the case of a railway system where the loads and profiles are more or less uniform. It facilitates the solution of traction and maintenance problems. When the system is not uniform, dividing the necessary power between two locomotives makes the working more flexible. At the present time this has to be done whent he power required exceeds 2 000 HP.

Multiple unit locomotives, which cannot be run as separate units, have not yet made an appearance in either Europe or Africa.

2. There is an obvious advantage in reducing the number of series of locomotives. There is also an advantage in having standard equipment, common to several series, at least in the case of the auxiliary equipment.

3. Under commercial transport conditions as found in Europe, it is difficult for one single type of locomotive to be suitable for hauling different categories of trains. It appears that it is necessary to provide a type of locomotive intended for fast or heavy traffic on the main lines (1 500 to 2 000 HP) and one or several types of locomotives for the mixed traffic on the main and secondary lines (800 to 1 400 HP) and for the traffic on the secondary lines as well as for shunting if required (400 to 800 HP).

4. As far as shunting is concerned, three classes of locomotives correspond to the different kinds of services required, the powers of which are :

— for shunting in the small yards and shops, 100 to 200 HP;

— humps shunting and branch line services, 400 to 600 HP;

— heavy shunting and transfer trips, 600 to 800 HP.

5. For a locomotive of given power, the arrangement of the axles depends upon the admissible axle load. For locomotives of average power running at less than 40 to 60 km (24 to 37 miles)/h the arrangement with parallel axles (rigid wheelbase), from type B to type D, is satisfactory. In other cases, bogies are advisable. When the permanent way is not suitable for the adoption of the BB type, the A1A-A1A arrangement is used. Finally, in the case of powerful locomotives running on heavy track the CC type is preferred.

6. Diesel engine technique can now provide reliable and powerful engines and the tendency is to abandon the use of two engines on a locomotive.

It is desirable to have robust, sturdy engines, which are easy to maintain. The desire to achieve high performances, even if this does not lead to such economical designs, should not involve complications which make the work of the maintenance and supply departments harder. This consideration is of particular importance for certain countries whose own special contingencies make it imperative for them to adopt simple and well proven solutions.

7. Several Administrations have put into service Diesel locomotives with two stroke engines. It is however not yet possible for them to make any statement regarding the final balance between the respective advantage and drawbacks of 2 and 4 stroke engines.

8. If the provision of a driving compartment at each end appears desirable in the case of heavy locomotives for express services, on shunting engines on the contrary the solution of a single driving compartment, preferably in the centre is recognised as the best.

9. The actual fields of utilisation of mechanical and electrical drives are fairly well defined: engines of less than

200 HP for the first, and engines of more than 800 HP for the second respectively. Between these two powers, the hydraulic drive can compete with the two other types.

For example designs have been made in which the hydraulic coupling and coupling transformers are used either separately or in conjunction with purely mechanical assemblies. The hydraulic drive, in certain cases called hydromechanical, is, when compared with electrical drive, cheaper to buy, and approximately equally convenient from the point of view of driving, regularity of working and efficiency. When the engine has to drive more than two axles, electric drives undoubtedly give a more elegant solution.

10. The fitting of a « dead man's handle » is considered desirable on those line locomotives driven by one man. It may also be of value in the case of locomotives with two men.

11. A shunting engine can be driven by one man. Usually, however the driver has an assistant on locomotives used for train services.

12. Completely common user makes for the best use of locomotives and personnel. It is a good thing to have the staff trained to drive different types of locomotives and railcars.

13. In the case of secondary lines, it is a good thing, when possible, to have the train services and the shunting in the adjoining stations worked by the same locomotives.

It may be of value to modify the method of working on certain lines, either to improve the service, or to obtain a better user of the locomotives.

14. It is possible to let the station staff drive the small engines attached to their stations. Such staff then has to be trained and supervised, and provision made for small maintenance jobs to be done on the spot.

15. In the first stages of dieselisation, it is reasonable to expect 20 % of time out of service and a user of more than 12 h out of 24.

16. At times when there is a peak passenger traffic, either the number of railcar services must be increased to cope with it, or a Diesel hauled rake substituted for the railcar. For this purpose, it is a good thing to provide as light weight rolling stock as possible, if possible of the current type. During the actual changeover period, the available steam locomotives can be used as reserves.

17. Solely on account of the greater availability of the Diesel locomotive, identical services can be worked with an appreciably smaller stock of locomotives in the case of Diesel traction as compared with steam. Compared with the numbers of steam locomotives, the numbers of replacement Diesel locomotives are generally in the proportion of 0.6 to 0.8.

18. The periodicity of the various inspections and overhauls can be determined either according to the mileage, or the number of days or hours in service. The mileage gives a very close indication of the state of repair of the engine and locomotive. The time factor is more convenient for the maintenance services. An intermediate method consists of basing the inspections according to the number of days or hours in service and the overhauls according to the mileage.

19. An analysis of the lubricating oils and a spectrographical examination of the ash form an invaluable method of investigation giving information concerning the advisability of a change of oil or the need of preventive treatment to such and such a component of the engine.

20. As with other methods of traction, maintenance consists in part of preventive inspections and in part of overhauls. Whether these are based on the « mil-

eage » or « time worked », there is a whole scale of inspections corresponding to a certain degree of thoroughness in going through the engine. Between two general overhauls of the locomotive, the engine has a part overhaul at between 80 000 and 120 000 km (50 000 and 74 000 miles).

21. In most cases, the intervals between overhauls laid down when the locomotives were first put into service are shown by experience to be capable of extension. It would appear that most economical method of maintenance is to carry out high quality repairs at fairly long intervals.

22. Provided a few modifications are made, it is possible to make use of the steam traction installations. Such modifications will relate to the arrival and departure sidings (installation of fuel supply pumps, oil, water and sand) and the sidings in the shed (installation of inspection gangways, mobile hoods to carry away the exhaust gases, etc.). In mixed sheds, it is recommended to separate the sidings and installations used for Diesel traction.

23. The stocking and distribution of fuel oil requires at least two tanks, one being in reserve. Based on the number of days of average consumption, the total capacity of a fuelling centre varies between 20 and 40 days; the settling period is about 12 days. Users have a tendency to give up centrifuging the fuel and instead to perfect methods of filtering the fuel.

24. As the Railway Administrations find it necessary to renew a certain proportion of their steam locomotives, it is natural for them to make a change in the method of traction which will result in economies under the following three headings: fuel, driving costs and the services in the sheds.

a) In the case of fuel, the savings are indisputable in the case of shunting services, no matter what the tax on fuel oil, which is often very heavy.

In the case of the train services, the savings are much less; they may even be cancelled out if the taxes are very heavy.

b) In the case of drivers, the savings can be very considerable when the locomotives can be driven by one man.

Even in other cases, they are substantial simply because of the better user of the men.

c) Important savings, which may be as much as 40 to 60 %, can be made in the services in the sheds.

Nota. — Savings can also be obtained under the heading maintenance. These cannot however always be counted upon (in particular owing to the cost of materials).

25. — To these strictly economic considerations must be added others such as the conditions under which passengers are carried, the improved working conditions for the driving and maintenance staff, and the greater flexibility of operation. In African countries doing away with the difficulties involved in obtaining water and coal supplies are also an important consideration.

26. In the present stage of affairs, it is difficult to estimate the economic repercussions of dieselisation on other departments than the Traction Department. In particular, it is still too early to say how the cost of maintaining the permanent way and the operating receipts will vary, other things remaining equal. At least, there is a considerable reduction in the risk of fires along the track.

27. In general, moreover, the difficulty experienced by the Administrations in presenting complete financial balance sheets shows that it is still too soon for the complete conclusions regarding the economic aspects of dieselisation to be drawn up.

Competition in the transport field in Sweden and its economic effects,

by Arne SJÖBERG,

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(Zeitschrift für Verkehrswissenschaft, No. 1, 1955*).*

When considering the restriction of competition practised in Sweden in recent years, it has often been remarked that in our modern State with the type of institutions it postulates, there cannot be competition of the kind admitted by the classical economist. To quote the American economist J. M. CLARK, it would be a truism to say that the most effective form of competition which we can have or obtain represents various imperfect types of competition seeing that there is no completely free competition. The problem of competition consists therefore in arriving in each concrete case at so organising this imperfect competition that it will produce the effects and work in the manner which we ourselves think desirable. Competition must be judged by the results which it produces in various respects. It must be decided to what extent it can be allowed from the point of view of the political economy of the country, the field in which it is to function, and in particular under the conditions created by existing institutions.

The criteria for such desirable and practically possible competition can be summed up as follows : the productivity of undertakings must constantly increase, their goods must constantly be improved, and the consumers must share in the increase in productivity by a reduction in the price and improvement in the quality of the goods, the staff must profit by equitable working conditions and sufficient security, etc. In such an economy as our own, « healthy » competition of this kind, which has no harmful repercussions from the general point of view, has an important mission to fulfil.

At all periods transport has been controlled and regulated by the State from various points of view. This was the case for example during the liberal XIXth Century, and classical economy looked upon this as the normal state of affairs. For example, Adam Smith states that the third and last duty of the State is to set up and maintain the necessary arteries for the general traffic requirements of the country. He also states that most of these public undertakings should and can be self-supporting so that they will not impose an additional burden upon the taxpayers. He also proposes that the payment made for using such undertakings should follow the principle of « that which the business can afford to pay » which makes it « very easy to make the indolence and vanity of the rich assist the poor by reducing the cost of transport of heavy goods to destinations all over the country. »

In nearly every country, therefore from very early times there has been State control of « new undertakings », which has affected important traffic arteries and their operating, for example the turnpike roads and canals in England and France and the canals in Sweden. When in the thirties of the last century the railways began to be built, the same method of concessions was also made use of. In view of the capital needed by such undertakings, in most European countries the

State intervened, either as owner or lender, and in several cases as operator of the completed railways.

On the other hand, inland navigation in nearly every case remained free from the obligation of obtaining a concession, whereas concessions were nearly always required in the case of road transport undertakings and airways.

The reasons for such state control of the new undertakings at the beginning was due above all to the general political economy, military policy, and social considerations. This was particularly so in the case of the railways. However, as the authorisation gave the undertaking in question a more or less absolute monopoly in its field of action, the State reserved the right to exercise a certain supervision and some measure of control over the rates of the undertaking and its services, so as to protect those making use of the transport facilities offered.

The law for combating the limitation of competition in various cases of the economic life of the country, due to a proposition of the experts as regards new undertakings (*Statens Offentliga Utredningar,* 1951, No. 27) which was passed by Parliament during the 1953 spring session, was intended to avoid the restriction of competition practised by one or several undertakings which had harmful effects from the general point of view. This law includes in its scope both State, communal and private undertakings. The legislation on the other hand is not directed against regulations concerning the economic activities of certain public authorities, due for example to economic, social, political or sanitary considerations. It often happens that free competition is completely cut out by such public regulations. In other cases, such restriction of competition may be the indirect consequence of certain regulation. The experts on new undertakings (Neuetablierungssachverständigen) state therefore in their Notes that « such restriction of competition which is the immediate and intentional result of public regulations, or which is its inevitable consequence, due to the carrying out of the regulations, cannot be regarded as harmful within the meaning of the law. On the other hand, restrictions of competition which have the character of a mediate and non-intentional consequence, and non-inevitable in any case, should be the subject of study by the Commission for Economic Liberty (Näringsfrihetnämnd). This for example covers a restriction of competition due originally to certain protective regulations of the State but which has been practised longer than was originally intended and is no longer necessary or is used inappropriately.

It should be noted here that one of the experts made a point of stressing in the Notes that the removal of such a restriction could not fail to lead to certain difficulties in practice. He also drew attention to « the very special situation due to the fact that the State itself contributes in various fields to setting up a restriction on competition, whereas in other fields, legislation must be enforced to forbid restrictions of competition which in themselves are much less radical. Such differential treatment would not appear possible of retention in the long run. It is therefore inevitable that either the restriction of competition practised with the approval of the State must be considerably reduced so as not to find itself in contradiction with what the public authorities have laid down in other cases, or such conditions must be adapted in such a way that the differences between what the State itself does and what it requires others to do is not too marked. »

Referring to the statement which we have just quoted, the Swedish Commercial Council remarked when discussing the report of the experts on new undertakings that similar considerations can also be advanced in the case of the public regula-

tion of professional motor traffic. This is regulated by a State control of new undertakings through the judicial authorities which appears from many points of view to be more effective than control of new private undertakings. It should be added that the hauliers have formed their own organisation similar to a trade union in order to limit competition even more in certain cases.

When putting forward the proposals for the new law (Kungl. Maj. : ts proposition No. 103/1953), the head of the Ministry declared in his report that State regulations considered necessary for various reasons should be so established that competition was not restricted any more than necessary. It appears of interest to point out here that it appears that in the *transport field* the State is much stricter in the case of the national transport undertaking (The Swedish State Railways) than in the case of private undertakings. These differences in the regulations affecting competition between the Swedish State Railways and private transport undertakings has had, as we will show, profound repercussions upon competition and the division of traffic, as well as upon the finances of the State Railways.

The economic consequences of these differences in the public regulations affecting the transport market do not appear to have received sufficient attention to date. One year ago, the Management of the State Railways dealt with these questions very thoroughly in a letter addressed to the Government in reply to a demand for a rapid discussion of the declarations of the Parliamentary State Commission in the spring session of 1953 on the establishment of a plan for the conversion of the narrow gauge railway lines to standard gauge. When considering the budget for the capital to be invested according to the 1953 State budget, the Commission was of the opinion that a definite programme should be drawn up for the change over to standard gauge, so that the State services had a definite basis upon which to estimate the financial conditions under which this work could be carried out whilst not overlooking capital requirements for other purposes of the State Railways. The latter in turn stipulated that a definite study should be made to decide which narrow gauge lines were to be ultimately converted to standard gauge and which should remain narrow gauge, as well as those which ultimately were to give way to other methods of transport for reasons of the general transport policy or economic reasons.

In the report on this question presented on the 30th May 1953 by the Railway Administration, which we will discuss in greater detail later on, they stated that after a profound study of the present position of the State Railways and the general economic and political conditions of transport under which the railways work, they had come to the conclusion that the State Railways could not at the present time undertake to carry out the programme in question without giving up the objectives so far laid down in the policy of the undertaking regarding the balancing of expenditure and paying back of capital, nor without neglecting other valuable investments. The Administration also pointed out that the question of knowing to what extent better conditions could be hoped for in the future depended to a large degree upon the organisation of the future transport policy. Under these conditions, the railway Management thought that it was not possible at the present time to draw up the programme required by Parliament for the conversion of their narrow gauge lines to standard gauge, and they asked for a reprieve until such time as the general transport policy applicable to future activities of the State Railways had been elucidated.

Economic objective.

The economic objective long since decided upon for the activities of the State Railways is that the whole of the expenditure, including repayment of capital invested by the State in the railways, must be covered by the receipts, at least in the long run. Consequently, if the surplus each year does not necessarily have to amount to a sum which will suffice for the capital repayment, it has always been held that it must at least cover the whole of the operating and maintenance costs including the cost of any renewals of the installations required.

This object has been attained over a long series of years. When we consider the results obtained by the State Railways during the period 1930 to 1939 (new rates came into force as from 1930), it will be seen that during this period the State Railways succeeded not only in covering their costs including the repayment of capital invested by the State, but were able to give the Treasury a profit of about 50 million crowns. For the period 1940 to 1951, dominated by the exceptional traffic due to the war and first post-war years, it was also possible to cover all the costs and repayment of capital and show a profit which amounted to the very considerable sum of about 475 million crowns. In addition, during this same period, the State Railways handed over to the Treasury in the form of transport taxes some 234 million crowns. In reality, however, some of the 475 million crowns mentioned above should be considered as sinking fund (about 200 million crowns) seeing that the sinking fund between the 1st July 1945 and the 30th June 1951 was inadequate as it was based upon the cost price of the equipment.

Although the traffic carried by the Swedish State Railways is still considerable, under present conditions, it is not possible to assure the repayment of the whole of the capital invested by the State. The explanation for this lack of equilibrium in the financial management of the Swedish State Railways is due to the economic evolution of the last few years and to the ever increasing competition from motor transport. The obligation to carry and to keep to the tariff has prevented the State Railways from fighting such competition on an equal footing, which may lead in the future to a progressive deterioration, to a much greater degree, than up to the present, in the finances of the State Railways.

Special obligations of the State Railways as a public service.

The position of the State Railways in the economy of Sweden has been characterized ever since the founding of the undertaking by a certain duality, owing to the fact that this undertaking is on the one hand part of the working of the State, and on the other, a public utility managed by the State (Public Service). In the Proces-Verbal of the Council of State on financial affairs of the 30th June 1953, the State undertaking is defined as : « a common enterprise of the community » and it is stated that « the object which dominates the economic activity of the State is to serve the needs of the community. » The State Railways as a public service have been given much greater social and political obligations than those imposed on the road firms competing against them. For example we might mention : the obligation to carry, the obligation to adhere to the tariff, the obligation to publish the rates, and the condition of equality of treatment of all users. As we have stated above, this inequality in the general obligations of the railway and the motor vehicle means that these two methods of transport cannot compete against each other on identical terms, which has had very serious repercussions upon the finances of the State Railways and has led to a division of the traffic between the rail-

way and the motor which from the point of view of the national economy is from many points of view very anti-economic.

The obligation to carry.

The obligation to carry means that the State Railways must accept, in general, on their extensive and very branching system all the traffic offered. This obligation to carry does not only mean that they are obliged to keep lines with very little traffic open, but also means that the State Railways must cope with the very exceptionally heavy traffic of holidays and other seasonal peaks during times of economic prosperity, as well as during exceptional circumstances such as interruption to the traffic due to snow and ice, as well as during strikes. In addition, when studying their installations and the organisation of the working, the State Railways have to take into account the general supply position and availability for national defence. It can therefore be said that the State Railways form a *communal* reserve for all methods of transport.

Owing to the existence of this obligation to carry, the installations of the State Railways and their permanent organisation, as well as the train services (as regards the number of trains run, etc.) must often be on a larger scale than would be necessary if the economics of the undertaking were the sole consideration. The obligation to carry also leads to increased operating costs.

Tariff obligations.

Tariff obligations mean that the State Railways are obliged to apply *standard* rates on all the lines, in spite of the important variations which occur in the costs and competitive conditions, according to the different lines, the different seasons, and in different economic situations. These standard rates are based on the average operating conditions of the railways as a whole and are in consequence from the point of view of cost, too high in the case of lines with heavy traffic and too low in the case of lines with very low traffic.

In addition, the rates applied by the State Railways based on the general tariff, as well as special reductions allowed by the tariffs, unlike its competitors' rates, have to be made public. In addition, those making use of the State Railways are assured from the point of view of special reductions (rebates) of *identical treatment* from the rating point of view under identical conditions.

These special obligations imposed on the State Railways as a public service are the result of social and political economy considerations and were intended to assure equilibrium in the traffic and the cost of transport for users in various parts of the country. The reasons for the *ad valorem* rates, the prices falling steeply with the distance and the rate based upon the distance of transport and uniform for the whole of the system, are therefore to a large extent anti-economic from the point of view of the undertaking itself.

From the point of view of political economy by basing the tariff on values, it was hoped to obtain cheap transport for raw materials and semi-manufactured goods, and by decreasing rates to encourage long distance transport, which is of particular importance in a long, narrow country like Sweden. Uniform transport rates based on the distance from the social point of view are intended to equalise the cost of passenger transport between the different parts of the country, and from the point of view of the political economy to make the situation of economic undertakings in various parts of the country as uniform as possible. Formerly, before the motor vehicle appeared on the transport market, reasons of industrial economy could also be invoked to justify tariffs based on values

and decreasing rates : they were a means of assuring a satisfactory user of the capacity of the important fixed installations of the railways.

To make rather a general statement, it might be said that this equalising of the services and cost of transport is obtained by making every effort to adopt uniform tariffs, so that the strongest part of the system from the economic point of view shows sufficient profit to make up for the deficit shown by the weakest part. This general equalisation of the service and rates applied not only to users in different parts of the country, but also to a certain extent to different types of traffic.

This vast system of compensating tariffs is as old as the railway and is the common practice when there is a « natural monopoly » such as that enjoyed by the State Railways before the development of motor traffic. The existence of such a monopoly was one of the conditions necessary to realise the compensating in question. The compensating of the costs and services between the different parts of the country and the various kinds of activity has been up to the present one of the fundamental factors in the organisation and carrying out of all railway activities. Without it, it would not have been possible to build railways in the sparsely populated parts of Sweden or serve places off the beaten track. The population of such regions would have been in an even worse position than it is now from the point of view of the cost of transport and the services. The ad valorem tariff in particular with the low rates for heavy traffic, as well as the decreasing differential rates, decreasing with the distance, have played a most important part in the creation of industry and its subsequent development.

The fact that the State Railways have now lost their former monopoly in practice means that the reasons for maintaining these special obligations of a general character have changed to a great extent. The obligation to carry and the obligation to apply a fixed tariff have made it impossible to compete against the motor vehicle on equal terms. These restrictions upon the State Railway's actions and chance of adapting itself constitute an ever increasing charge upon railway finances, especially in the last few years.

This situation is due above all to the fact that the nationalisation of the railway has extended the former regional compensation of the old system as regards the services and rates, which was in a better position to cope with motor competition, to a very large network which in practice includes nearly all the railway lines in the country. Owing to the nationalisation of the railways, regional compensation has also been extended from the point of view of the wages, service conditions and social benefits for the railway staff.

Lines with little traffic which now, owing to the nationalisation of the railways, represent a relatively larger proportion of the system than in the thirties, thus are a considerable economic liability, from the point of view of the undertaking, for the State Railways. Formerly, the old private railways, applying rates and paying wages comensurate with the economic possibilities of their lines, were able in many cases to balance their budgets. Under the administration of the State Railways this is impossible, since the rates and wages in force when they were private railways have been swept away and automatically replaced on the one hand by the State Railway rates which are generally much lower, and on the other hand by the uniform wages system of the State Railways and standardised service and working conditions for the staff, who are much better off thereby.

The following example shows what it means to apply the rates and wages scales of the State Railways to a former private railway. The Stockholm-Roslagen Railways which carried a relatively heavy

traffic and extended to some 326 km (203 miles) on the whole managed to balance their budgets during the last few years in which they were run as a private undertaking. But in 1952, under the administration of the State Railways, this line required subsidizing to the extent of 3.5 million crowns.

Anti-economic distribution of the traffic between rail and road.

The differences between rail and road from the point of view of the conditions under which they compete against each other, can be summed up as follows :

Unlike the railways, the professional road hauliers are under no obligation to publish their rates, nor have they any obligation to grant all their clients equal terms from this point of view. Nor is the lorry bound in any way to the railway tariffs which are the same at all seasons of the year (constant in time) and on all the lines (constant in space); individual rates can therefore be granted for each transport. They also ignore completely the graduation of the rates according to value.

Owing to the absence of any restrictions upon fixing the rates, the road haulier so long as he keeps within the maximum fixed tariff — which has been fixed at such a level that it makes it possible for him to cover his costs even under exceptionally unfavourable conditions — can vary his rates within much wider limits if he finds this desirable from the point of view of competition. It is thus very easy for the road haulier to choose the point at which he will compete against the railway.

The differences between the railway and the road haulier as regards the obligation to carry and the tariff obligations thus are detrimental to the railway and protect the road haulier when he competes against it. These differences prevent the railway from fighting road competition under equal terms. A rational division from the point of view of the general economy of the country, of the traffic between the railway and the road is thereby rendered impossible. This makes it impossible for transport to be worked by the method or combination of methods which in each particular cases implies the sacrifice of the minimum possible amount of productive effort from the community as a whole.

On long distance services with heavy, regular traffic, where the State Railways as a rule can carry out transport over their electrified lines cheaper than it can be carried by lorry, both from the point of view of the economy of the undertaking and that of the general economy of the country, it often happens that it does not get the traffic because the standard rates of the railway make it impossible for it to compete and special reductions cannot be granted owing to the obligation to treat all clients alike. To this must be added the difficulty the State Railways find in competing effectively against the road owing to the fact that they are obliged to publish their rates whereas road hauliers are exempt from such an obligation.

Consequently, in regions with little traffic, the standard rates of the railway, its obligation to carry etc., result in certain traffic going by rail which could be much better carried by road, both from the point of view of the economy of the undertaking and that of the general economy of the country.

The progressive raising in recent years of the State Railway charges, due to the deficits shown by such lines have also made it necessary to revise the old system of rates based upon the value of the goods transported, the rates for industrial raw materials and other heavy goods having been increased to a relatively greater extent than those for other goods, where motor competition is more strongly felt.

The very unequal distribution of the traffic between the different lines of the

railway is a factor which is economically of particular importance for the finances of the State Railways. As most of the operating costs of the railway do not increase in proportion to the traffic, the cost of the unit of traffic is appreciably greater on lines with little traffic than on lines with heavy traffic. The fact that 75 % of the traffic of the State Railways is worked by one quarter of its lines shows to what degree the distribution of the traffic between the different lines is unfavourable.

It is not possible to trace any definite economic demarkation from the point of view of the undertaking between lines with heavy traffic and lines with little traffic, because it is impossible to justify the statement : line with heavy traffic = profitable line or line with little traffic = line showing a deficit. The structure of the traffic may in many cases be such that a line with very little traffic may have much lower costs or produce much greater receipts than a line with much heavier traffic. The Management of the State Railways has organised an enquiry with the object of determining the relative profitability of their different lines, in order to ascertain what improvements could be made from the point of view of the economy of the undertaking, by applying different rationalisation measures on railway lines with little traffic. At the Session held in Stockholm in 1952 by the International Railway Congress Association, the question of closing down railway lines with little traffic and replacing them either wholly or partly by motor services was dealt with amongst others. As regards the delimitation between rail or road working for such services, the Congress declared in its final recommendations :

« Studies and realizations which have been made by certain Railway Administrations in the case of feeder lines with very little traffic have indicated that where the total annual traffic is less than 250 000 traffic units per annum and kilometre of line, then it is often more economical to ensure traffic by road than by rail, on the basis of retaining railway rates. »

The standard set must naturally be considered as completely theoretical. On the State Railways no estimates are made at the present time of the number of units of traffic (passenger-kilometres + freight tons-kilometres) for the different lines of the railway, but with the aid of the available statistics it is possible to get an appropriate picture of the lines which do not reach this limit of 250 000 traffic units per annum and per kilometre of line worked.

An approximate calculation of this sort, although incomplete, in view of the fact that some short lines with little traffic are included with others as far as the statistics are concerned, shows that the lines in question represent a total development of some 6 440 km (4 000 miles), which corresponds to the considerable percentage of 42.6 % of the total State system. For a great number of these lines, if the economy of the undertaking as a whole is the sole consideration, the total or partial suppression of railway services and their replacement by road services, in so far as roads are available, would be justified. The traffic on these lines, in gross ton-km only represents 5.6 % of the total traffic of the State Railways (apart from the mineral traffic) but it can be estimated that it accounts for about 20 % of the total operating costs.

The greater part of the lines in question, nearly 70 % of them, have only been included in the State Railways since 1939. The remaining 30 % consist above all of the lines in the north of Sweden which were built for other than purely economic reasons.

As the Swedish State Railways during the last few years have not kept complete accounts of the costs and receipts for the different lines of the railway, it is not possible to state with sufficient certainty the total amount of the profits

from the working of the lines with heavy traffic which show profits which have made up for the deficits on those parts of the railway where there is less traffic. To get some idea of the importance of such compensation, estimates have been made of the profits on lines with heavy traffic based on the conditions in 1951. From this approximate calculation such lines, which only represent some 10 % of the system, but carry one third of the total traffic of the State Railways in gross tons-kilometres, showed an operating profit of about 200 million crowns, which was used to make good the loss on the lines with little traffic.

Suggestions for competition on equal terms between the railway and the road.

The present financial position of the Swedish State Railways is particularly unstable. A great many of the receipts depend to a large extent on economic circumstances, and the disappearance of these receipts and even a slight decrease in economic activities would result in the receipts of the Swedish State Railways dropping by some 100 million crowns a year, which could only be made up in part and progressively by a reduction in the costs.

In order to obtain increased output and to improve their economic position, the State Railways have undertaken a general check up of the different factors of the economic structure of the undertaking, of the methods of production in their operating, of the rates for passenger and freight traffic, methods of selling, organising, etc. With such an adaptation of the costs and receipts, it appears that it is not possible to obtain increased receipts for the undertaking by means of a general increase in the tariffs, even if the publicity given to the matter made it possible to get certain improvements. The adaptation must therefore be essentially by means of a reduction in the costs. In this field, special mention must be made of the general study undertaken of stations and lines with little traffic, in order to decide what economies could be realised by suppressing the railway services either wholly or partially and serving the regions in question by bus and lorry services.

However, the improvement in the financial situation of the State Railways which may be achieved by the rationalisation methods now being introduced does not appear to be sufficient in the long run to assure the real balancing of its budget and repayment of the capital invested by the State. A lasting improvement and a satisfactory balance sheet for the financial management of the State Railways would only appear possible if they are freed from the burden of the economic losses due to their public burden from their obligation to carry, etc.

As we remarked above, motor competition means that it is no longer possible to get sufficient profit from the economically sound branches of the undertaking to compensate for the increasing losses from the weaker branches.

The compensation of the traffic services and transport costs, which is justified for social reasons and reasons of political economy, is no longer possible with the system applied to date, and in view of road competition, it is necessary for the State Railways to base their rates and services on the different economic subdivisions of the undertaking, being guided solely by their inherent operating conditions. This way of proceeding appears also justified from the point of view of the general economics of transport. The object should be to obtain a proper distribution of the traffic between rail and road, so that the traffic is carried by that method of transport or that combination of methods of transport which will be the cheapest for the community as a whole.

If for reasons of political economy, social reasons, or reasons of national defence, it appears desirable to apply lower rates or give better services to

certain weaker branches of the State Railways than the economy of the undertaking as a whole warrants, or even to retain certain lines which show a loss, then it would appear that the resulting deficit should be made good by special allocations from the general State budget.

If the solution which we have mentioned is not adopted, i.e. to maintain by means of subsidies from the State the old regional compensating tariffs and services between the different sections of the State Railways, then it would appear that some form of adaptation of the whole transport apparatus to traffic requirements and an economic distribution of transport between rail and road alone will make it possible to retain such compensation completely or in part.

Apart from the methods indicated, special allocations from the budget for transport not justified by the economics of the undertaking, or some method of sharing the traffic economically between rail and road, a lasting improvement in the finances of the State Railways and a satisfactory balance sheet could still be obtained by doing away with the present duality in fixing the objects of the activity of the State Railways, could the latter on the contrary be run as a purely commercial undertaking. This would mean that the State Railways would be freed from their obligations as a public service and consequently would be able to fight other transport undertakings as a purely commercial undertaking themselves, under *equal conditions*. It appears however that this latter solution : competition under equal conditions between rail and road, and as a result improvement in the finances of the railway, founded on the hypothesis that the railways would be freed from their present obligations as a public service, is only of theoretical interest. For social reasons, for reasons of political economy, and for general reasons of supply and the national defence, it would only appear possible to free the State Railways from their obligations as a public service to a very limited extent. The problem of the equilibrium of internal transport which depends upon the transport policy and includes that of the general obligations of the State Railway undertaking which is an integral and very important part would therefore not appear possible of solution by the purely theoretical methods mentioned above, and it seems that in practice solutions must be looked for in a combination of different measures in various transport fields.

[656 .256 .3 : 625 .42 (45)]

Automatic block installation on the Rome Metro,

by Dr. Ing. Giulio Cini,

(*Ingegneria Ferroviaria*, No. 4, April 1955.)

Summary. — The proposals for installing automatic block equipment have been the subject of very intensive studies to take advantage of the practical results obtained from the systems used on other large urban underground railways all over the world and also to take into account modern technical progress in railway signalling.

This difficult problem has been brilliantly resolved by a system which retains the basic standard features of existing installations, but which also includes, without undue additional expenditure, the items necessary to provide a permissible train frequency more than double that of the present frequency, with safeguards which are, in some respects, greatly increased.

* * *

From the signalling point of view, urban railways present particularly severe and troublesome demands. The high speed of the trains (80 to 100 km/h [50 to 62 m.p.h.]), the high traffic density, which is at the rate of a few minutes intervals, the reduced accessibility of the line — at least in the underground sections — are factors which must be carefully considered in selecting a system which will give absolute security as well as maximum operating regularity.

During the nineteenth century and at the beginning of the present one, when the urban railways of London, Berlin, Paris, Barcelona, etc. were built, the spacing of trains, governed by automatic block sections operated by track circuits, represented the greatest application of the technique, and it is exactly this system which has been used.

At the same time, whilst it is true that a block system of this kind has the advantage of assuring *continuous* indication of the state of the track occupation and is thus clearly superior to intermittent pedal-operated equipment, it is limited to a continuous indication at certain fixed points on the line, at the entrances (in the direction of travel) to the various sections protected by appropriate signals. This presents no disadvantages if the state of the track in front does not change after the signal has been passed. Changes of this kind can, however, occur and these can only be communicated to the driver with some delay which, even if it has no other consequences, hinders the rapid flow of traffic.

A definite advance was achieved by the adoption of signalling on the motive unit by means of which the driver is immediately informed of any alteration to the state of occupation or freedom of the track, *wherever the set may be.*

In addition to these improvements in regard to the continuity of signalling, however, significant improvements have also been achieved subsequent to the opening of the urban railways in the cities mentioned above, in the *imperative value* of the signalling equipment.

It had from the outset been appreciated that is was necessary to ensure that signals would be obeyed, this being an essential condition in obtaining full value from the very high degree of safety achieved in the operation of the signals themselves, and special devices were adopted for automatic stopping of trains, by automatic brake application if a stop signal was ignored. Experience shows, and has

always shown, that inattention, a momentary relaxation or weakness on the part of the driver, is always a possibility and that the consequences may be extremely severe, particularly on lines with heavy traffic, such as those now under consideration.

However, the use of a « train stop » (fig. 1) only partially overcomes the difficulty, because the automatic brake application is made at the last moment and only at certain defined points of the line. If, in addition, the signals are permissive the manual lowering of the signal arm must be allowed when the train has come to a halt at a stop signal so that it may proceed at caution; it is then necessary, at the cost of severe disadvantages, to maintain throughout the section a greatly reduced speed, even though the conditions in front may be alleviated. There is therefore no possibility of overcoming a consequential slight delay; on the contrary the delay has a tendency to grow.

Modern signalling on the locomotive or motive unit, with continuous control of speed, widely used in recent years in other countries, even on main line railways, undoubtedly represents a notable advance from many points of view. Cab signals, with three or more aspects already have, inherently, all the features which permit, not only the halting of a train, but also the imposition of a speed at the most equal to the maximum speed authorised for each of the possible indications (which are more restrictive than the completely open track) of the cab signal. The speed of a train is registered on a centrifugal governor which is driven at a speed proportional to that of the

Fig. 1. — Block signals and corresponding train stops : surface section of the Rome Underground. (*Photo Vasari, Rome.*)

train and makes or breaks groups of electrical contacts corresponding to average and minimum speeds of the train.

Appropriate arrangement of these contacts in the electrovalve control circuits acting on the brake pipe provides automatic brake application if the driver has not, within a determined period, reduced the speed of the train to below the maximum speed authorised by the conditions in advance, as indicated by the signal provided in the driving unit.

The adoption of this system provides numerous advantages.

In these conditions, it is no longer necessary to take into account, in fixing the length of section, the maximum braking distance for bringing the train to a halt from maximum speed, since it is certain that any train can only approach an occupied section at a speed reduced to a suitable limit, which in this case is about half the maximum speed. Moreover, a reduction in the length of the sections clearly increases the number of trains which can follow one another in conditions of perfect security and consequently increases the capacity of the line. In addition, indication of the possibility of increasing his own speed, and consequently of freeing sections in the rear (as is in mind when stopped at stations) is immediately obvious to the driver at whatever point he may be on the line, which allows the speed of the train to be maintained constantly at the maximum permitted for safe operation.

Finally, such a system eliminates the need for devices of the type known as the « dead man's handle ». This device affects not only safety but also economy of operation, because it becomes possible to entrust the driving of a train to one person instead of two. Existing types of « dead man's handle » must necessarily oblige the driver to show his presence and vigilance by making certain periodical movements which, although simple and fairly natural, always give rise to a certain boredom.

With the automatic control of speed, the dead man's device remains applied and requires no periodical operation by the driver. If, within a period of some seconds, the driver has not taken action to reduce speed to within the limits indicated by the signal aspect, the control applies an emergency brake until the train comes to a stop; safe running is thus assured even if the driver is taken ill.

* * *

It has been stated above that the best-known urban railways in Europe have not, because of the fact that they were built some decades ago, been able to apply the most recent developments in signalling technique, neither in their inauguration, nor later, because of the well-recognised difficulties of undertaking radical modifications during operation.

In the selection of a signalling system to be used for the Rome Underground Railways, a conflict of opinions inevitably arose between the advocates of systems which took into account mainly the experience gained in many years of intensive operation and those who, convinced of the superiority of more modern methods, favoured their application. Careful investigation of the matter led to the fortunate conclusion that the two terms, apparently contradictory, were in practice perfectly reconcilable taking into account the demands of the traffic in the initial stages, the probable future developments in the creation of new lines and the evaluation of the urban zone served by the first section.

With the initial frequency of trains, i.e. a time interval of at least three minutes, it was possible to adopt in all cases sections equal in length to the distance between successive stations, and consequently it was sufficient to provide protective and starting signals at the various stations only, to the complete exclusion of all signals on the line.

For possible increased frequencies of the future, up to a minimum interval of

90 seconds, the earlier system, following generally traditional lines but provided from the start with a number of track circuits larger than the number of sections, could be converted without needless expenditure to continuous speed control by simply adding to (and to some extent, even, replacing) the A.C. feed to the track circuits a current coded or periodically interrupted in accordance with a set rule and equipping the motive units with the necessary gear for protective signalling and the corresponding speed control. Naturally it is also possible to extend the initial installation by the addition of other block signals along the line, together with the corresponding equipment, automatic train stopping devices, etc.

The diagram in figure 2 shows in essence the installation in the first stage, which has been in use since February 10th, 1955. It shows a stretch of line between two consecutive stations with the double protecting and departure signals and the track circuited sections. These circuits are supplied with 83-cycle alternating current to avoid any interference from the 50-cycle high-tension cables which in places are located close to the track. The track relays, induction disc type, are in pairs, in series, for each track circuit. By this arrangement a higher degree of security is achieved against the possibility of wrong excitation, the possibility being avoided by the use of a coded current, as it might be called. In fact, the open position of the track circuit is expressed in the latter case by the continuance of a coded current of a fixed frequency and consequently by the periodical opening and closing of the contacts of a pilot relay. It is obvious that any defect whatever will never give rise to a condition of this kind.

The track circuits in the diagram, which is naturally purely diagrammatical, clearly show the conditions imposed for the clearing of signals and the lowering of the stop arms, the latter also being clearly shown in figure 3.

It is convenient to mention that, in accordance with the regulations for safety, the arm is held up by a spring and in the other position is pulled down by an electromagnet which remains excited during the whole time for which the signal is showing a clear road. In order that the signal may pass effectively to green or yellow, an indication of the lowering of the stop arm is necessary. The signals in tunnels are of the multiple aspect type and illumination of the different lights is indicated by a relay in series; in the open air, signals with a movable screen are used with colour filters which, as is known, give absolute protection against the « ghost » effect sometimes produced by the sun's rays. The inductive connections at the ends of each track circuit to ensure continuity of the traction return current, and yet maintain between the rails an impedance sufficient to keep the track relays excited when the road is clear, are of the resonant type, tuned to the 83-cycle signalling current.

Figure 4 contains a diagram of the coding arrangements for the track circuits used to obtain continuous signalling on the motive units and control of speed. Track relays A, B, C and D remain unchanged, as in figure 2, but the feeds which were direct vary according to track circuit occupation. Three forms of 83-cycle A.C. current are available, fixed or constant, periodically interrupted at a rate of 75 times per minute, and periodically interrupted at a rate of 180 times per minute. These periodical interruptions are obtained by pendulum coders, a sort of relay with oscillating armature which opens and closes contacts specially designed for service of this kind. For the higher frequency a pendulum weight is used, fixed to a highly resilient bar which works below its elastic limit; for the lower frequency there is a two-part movement. When a train T enters

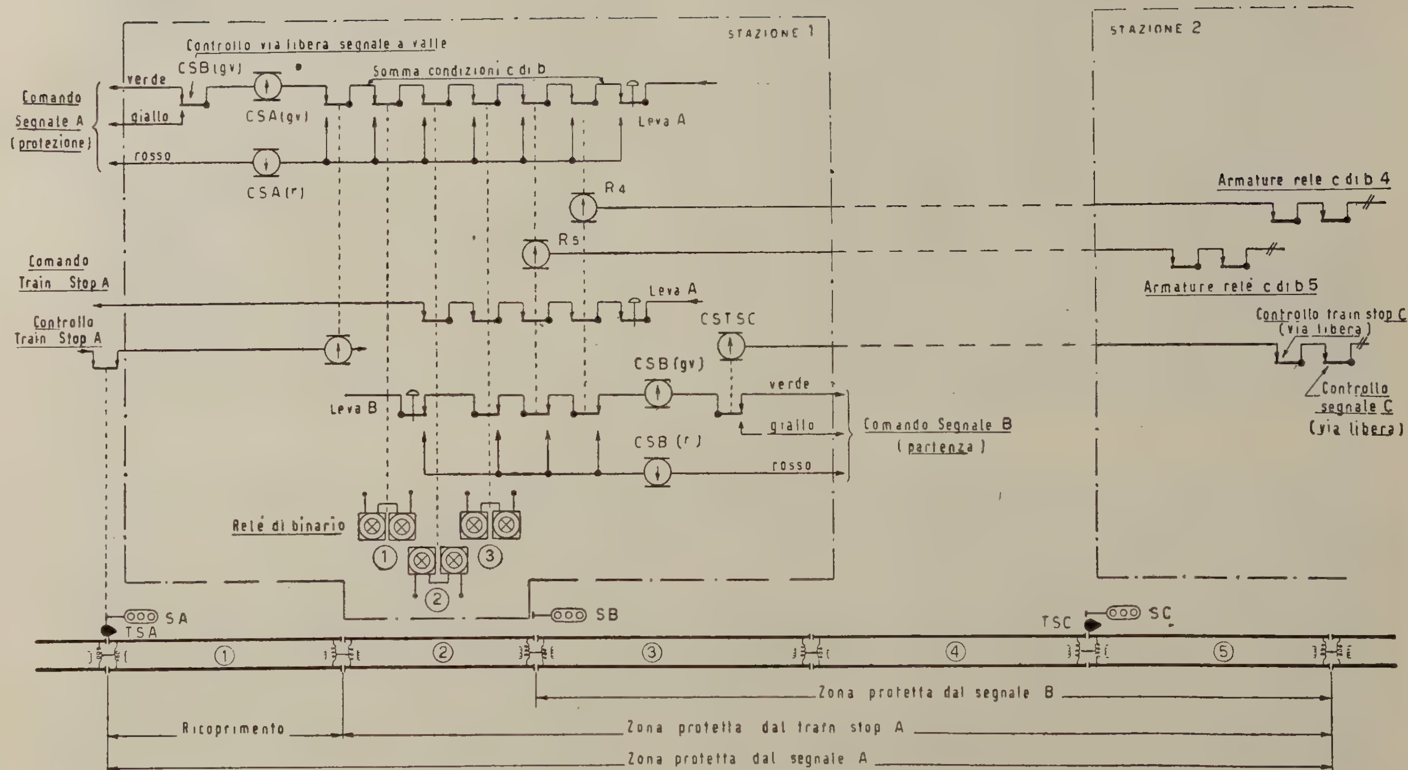

Fig. 2. — Diagram showing principle of automatic block, with constant current.

N. B. — Commando segnale A (protezione) = control for signal A (protection). — Commando segnale B (partenza) = control for signal B (departure). — Controllo via libera segnale a valle = clear signal ahead indicator. — Somma condizioni *c* di *b* = result of conditions *c* from *b*. — Leva = lever. — Relé di binario = track relay. — Verde = green. — Giallo = yellow. — Rosso = red. — Ricoprimento = overlap. — Zona protetta dal segnale = zone protected by signal.

a track circuit, for example the circuit on track 1, it cuts out the corresponding relay and thus closes the signal for the line as shown by the circuits in figure 2. Relay A, however, being cut out causes the excitation of another relay which feeds this track circuit with a current coded at 180 periods. The result is that in the circuit formed by the winding of the inductive connection on the feed side of No. 1 track circuit, by the two rails of relay B and causes the excitation of track relay *b*. This circuit which had until then been supplied with constant current, will now receive current coded at 75 periods, as shown by figure 4. The driver is immediately notified by the appearance on the cab signal of the yellow light that the section which the train has just entered, as well as the following one, is clear but that the second one is occupied; he will thus immediately reduce

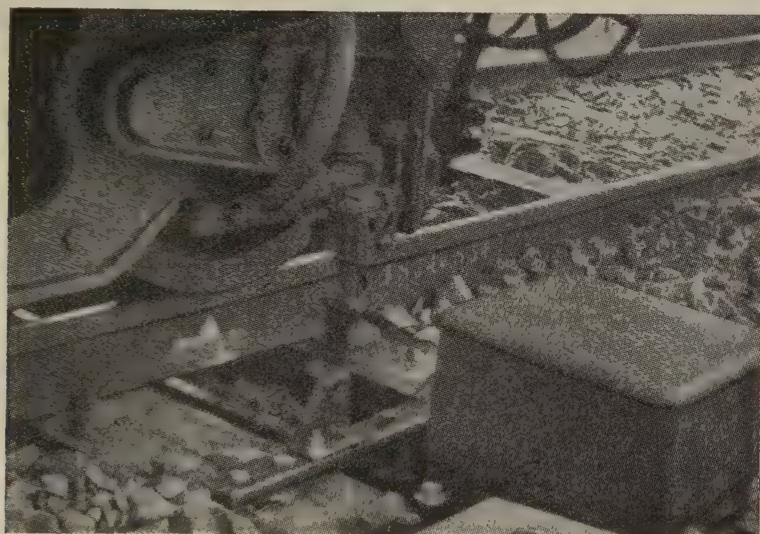

Fig. 3. — Details of train stop. (*Photo Vasari, Rome.*)

this circuit and by the first axle of the motor unit running on it, there is an 83-cycle alternating current at code 180. The equipment mounted in the motive unit, which will be described later, can detect this current and illuminate a green light in the cab and this indication remains naturally under the eyes of the driver until some new factor intervenes, thus giving a positive indication of the regularity of his running. Assuming that a train T' stops at a station, train T by advancing will at a certain moment enter No. 2 track circuit which cuts out track the speed of the train to below the limit fixed for this aspect in order to avoid the risk of emergency braking and stopping the train. When the last axle of train T has cleared No. 1 track circuit, the constant current is restored to this circuit, firstly through the de-energised contact of relay B and the excited contact of relay *a*; then, with the excitation of A and its consequent de-energisation of *a*, directly and definitely by the intervention of the de-energised contact of the latter.

Finally, if the train running at reduced

speed enters circuit 3, it will de-energise relay C, excite relay *c* (omitted from the diagram for simplicity) which in turn, owing to the contact of relay D de-energised by the presence in the section of train T' connects the feeder from this No. 3 circuit (not shown) to a constant current supply. The cab signal would immediately pass to red and the driver would then have to reduce the speed of the train to below 15 km/h to avoid automatic stoppage of the train; this done, however, he could continue under caution to halt in front of the obstacle or at a mandatory stop.

The brief description given above shows that the system allows at all times the maximum speed compatible with safety and even authorises it, with continuous indication.

Figure 5 shows, again diagrammatically, the equipment on motor units provided with signals and speed control.

In front of the outer axles of each motor coach is fitted in line with the rails and about 15 cm (6 in.) above them, a pair of collectors in the form of coils with iron core, wired so that their operation is cumulative. The current arising from the supply to the track circuit and flowing through the first axle has in effect an instantaneously opposed direction in each of the two rails.

These collectors cut the flux produced by the axial alternating current and thus become the source of an induced electromotive force which by means of an electronic amplifier operates a pilot relay; this is therefore set or remains de-energised, if there is no axial current or is excited continuously if the axial current is constant, or further, repeats that of the two codes, 75 or 180, if these exist in the rails of the section being traversed. To the oscillating contacts of the pilot

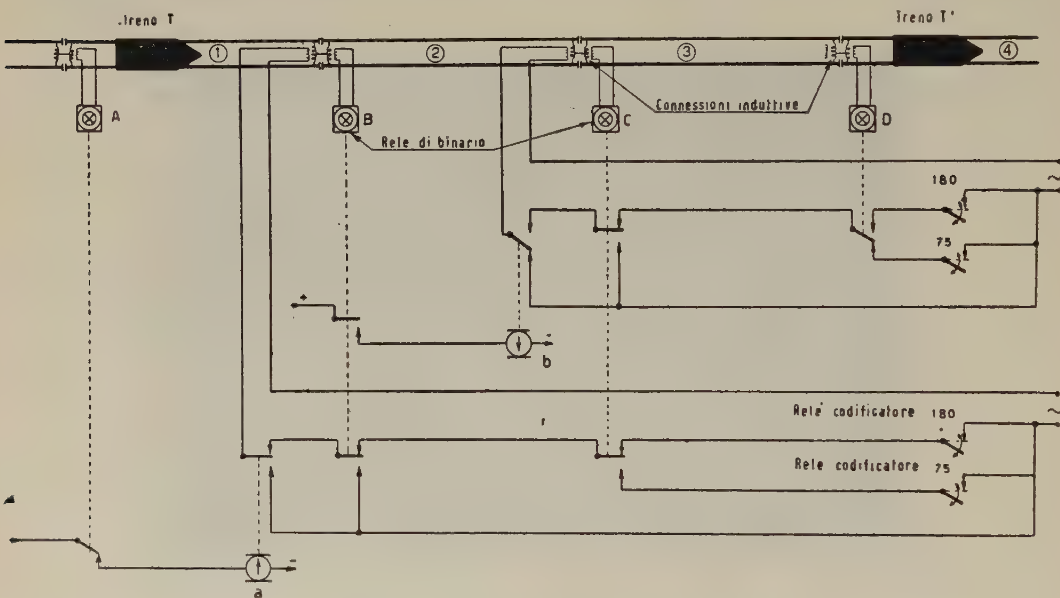

Fig. 4. — Diagram of automatic block, with code superimposed.

N. B. — Treno = train. — Relé di binario = track relay. — Connessioni induttive = inductive connection. — Relé codificatore = coding relay.

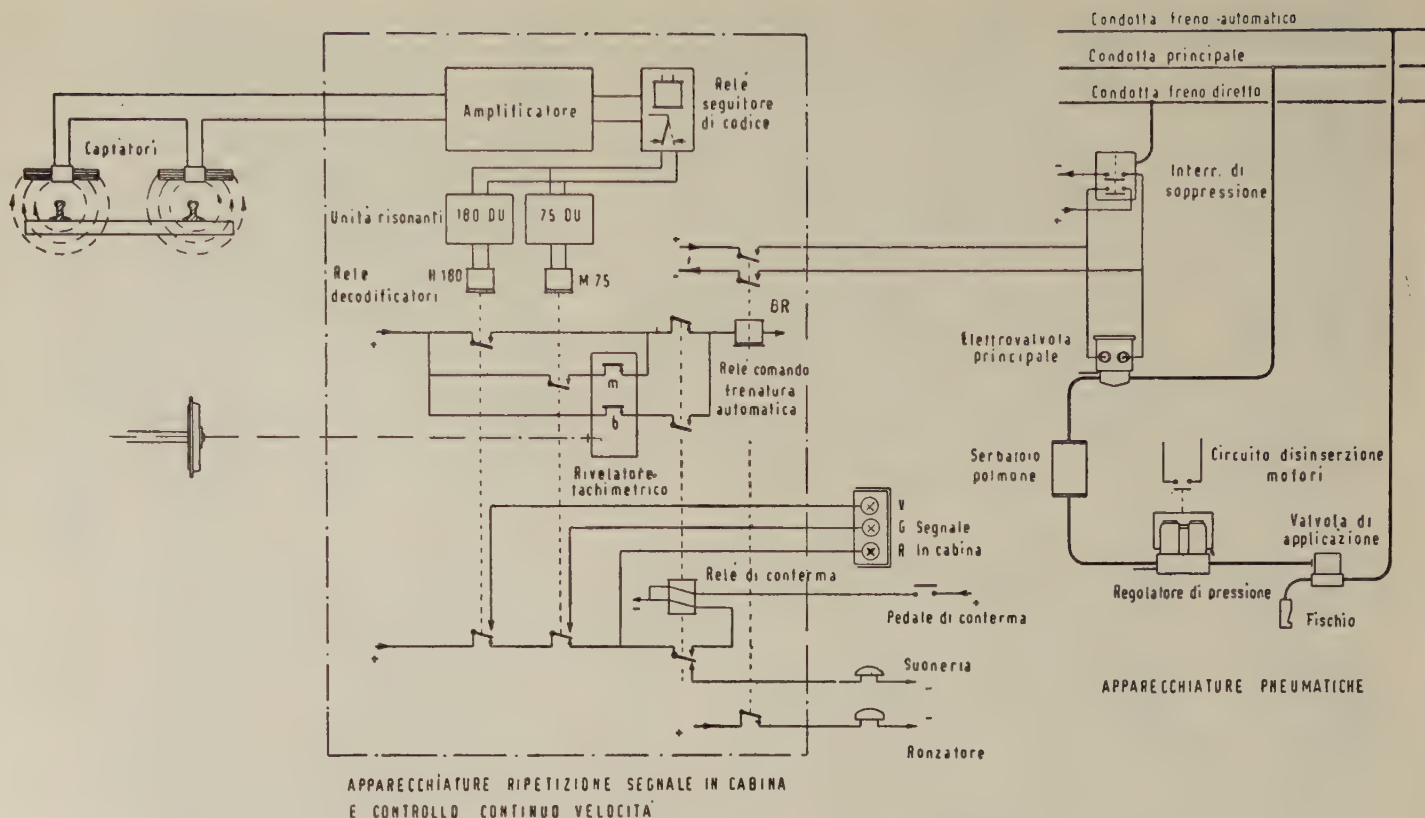

Fig. 5. — Diagram of electrical circuits and pneumatic equipment for cab signalling and continuous speed control.

N. B. — Apparecchiature ripetizione segnale... = signal repeating equipment in cab with continuous speed control. — Apparecchiature pneumatische = pneumatic equipment. — Captatori = collectors. — Amplificatore = amplifier. — Relé seguitore di codici = pilot relay. — Unitá risonanti = resonant units. — Relé de codificatori = decoding relays. — Relé commando frenature automatica = relay controllinga utomatic brake. — Relé di conferma = confirming relay. — Segnale in cabina = cab signal. — Pedale di conferma = confirming pedal. — Suoneria = bell. — Ronzatore = buzzer. — Condotta freno automatice = auto. brake pipe. — Condotta principale = main pipe. — Condotta freno diretto = direct brake pipe. — Interr. di soppressione = cancelling switch. — Ellettrovalvola principale = main electro-valve. — Circuito disinserzione motori = motor isolating circuit. — Serbatoio polmone = reservoir. — Fischio = whistle. — Regolatore di pressione = pressure regulator. — Valvola di applicazione = application valve.

relay are connected a decoding transformer and two tuned receivers, one to the frequency 75 and one to 180. It consequently follows that the relay M 75 or the relay H 180 would be excited in a stable manner only when the axle current is periodically interrupted at one or other of the frequencies [1].

An examination of figure 5 will show that of the three signal lights mounted on the motor coach, the red will light when neither of the code emitter relays are excited, the yellow will be substituted for the red when relay M 75 is excited and finally the green will show with the closing of the top contacts of relay H 180. It is evident that there can never be more than one indication at one time.

As we have already mentioned above, on one of the axles of the motor coach there is also a revolution counter, a kind of centrifugal controller provided with two groups of electrical contacts, the axis of which rotates at a speed proportionate to that of the vehicle in accordance with a fixed ratio. The device is designed so that when the coach is running at a speed below 15 km/h (9 m.p.h.) the two groups of contacts are connected, above this limit one group cuts out and the other remains connected and above 40 km/h (25 m.p.h.) both groups are disconnected. These values of critical speeds can very easily be varied between very wide limits.

The diagram in figure 5 clearly shows that relay BR, which, when de-energised, causes automatic brake application, can be excited either by means of the contacts of excited relay H 180, or by means of the top contacts of relay M 75 and the group of contacts of the revolution counter corresponding to the highest critical speed, or further by means of the group of contacts of the counter corresponding to the lower critical speed and a top contact of the confirming relay which is excited by the operation of a pedal and then remains auto-excited only if the relays H 180 and M 75 are both de-energised.

These three parallel lines of the circuit correspond to the three possible conditions in which automatic braking can and must be avoided; when the sections in advance are clear and the signal is green; when the signal, having passed to yellow, the speed of the train is reduced by the driver to below the upper critical limit and finally, when the signal having given the track occupied indication, the driver has momentarily operated the confirming pedal and rapidly reduced the speed of the train to below the lower critical limit. Any de-energisation, even temporary, of the relay BR is indicated by a buzzer; a louder acoustic signal, comprising a bell, is sounded when the signal changes to red and continues until the signal is acknowledged on the confirming pedal.

* * *

The brief survey which we have given of the Rome Underground signalling system and its effect on train intervals is now concluded.

As a simple additional point, we would like to add that the ten stations or halts have all been equipped with central locking posts with route-setting levers, having diagrams with comprehensive levers or separate keys for each route.

These include a new feature in using specially arranged relay circuits which automatically cover pre-arranged shunting movements in certain stations for strengthening trains in accordance with a plan which can readily be modified.

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[1] Further details on this subject can be found in publication DS, 17th Nov., 1950, issued by the Westinghouse Brake and Signal Co., Turin (in Italian).

[656 .25 (44)]

Developments in the sphere of track circuits, due to electronics,

by M. WALTER,

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(*Revue Générale des Chemins de fer*, September 1954.)

The insulated track circuit constitutes an essential element of signalling installations. With its aid, it has been possible to develop systems which, on the one hand, greatly increase the safety of railway operation and, on the other hand, procure important facilities for the dispatch of trains, and which moreover permit significant savings in staff (especially in connection with automatic block system, electrically operated signal boxes covering large areas, centralised traffic control).

The development of lightweight railcars has posed a difficult problem inasmuch as these do not always reliably ensure the correct working of the track circuits. Moreover, on electrified lines, the installation of track circuits for the automatic block system has hitherto been a fairly expensive proposition. (The high cost is due to the need to produce in special sub-stations, and to distribute by means of continuous feeders along the track, a current of a special type, different from that of the traction current).

Research undertaken by the S.N.C.F. has necessitated prolonged observations and systematic investigations due to the fact that failures of normal track circuits are, after all, rare. The circumstances in which they occur have been investigated by means of specially designed measuring and recording devices mounted on a railcar specially equipped foı the purpose.

These studies and investigations have led to the adoption of the following two rules :

— firstly, in order to reduce expenditure on electrified lines : use of track circuits at the comparatively high frequency of the musical frequency band;

— secondly, in order to ensure the proper working of the track circuits even during the passage of light railcars : use of circuits of a fairly high voltage (of the order of 30 to 100 V).

For track circuits at musical frequency, a simple and flexible solution has been found due to the use of « pentode » electronic valves, directly connected to the 50 cycle current supply.

Track circuits with relatively high voltage have been obtained in an economically advantageous way by using power valves or « thyratrons » which are likewise connected to the general 50 cycle supply system and which permit the use of intermittent impulses, resulting in a considerable reduction in the current consumption of the track circuits.

In the following, the author describes the investigations that have been carried out and the solutions to which they have led.

I. Introduction.

General features of the track circuit.

The insulated track circuit [1] — one of several very precious gifts bestowed by electrotechnics on the railways, the importance of which needs no emphasis — represents a fairly old invention. According to the historical data available on the subject, it was in 1867 that William Robinson, an Irishman by birth, expressed the idea of the D.C. track circuit in the United States without, however, initially deriving all the benefit which was to be derived from it later.

In the form in which it was developed in different countries during the twentieth century, the D.C. track circuit was based on the following general principle : the rails, assumed to be mounted on wooden sleepers, i.e. insulating sleepers, constitute in themselves a part of the « track circuit ». As shown in figure 1, the rails transmit the current (normally supplied by a single battery or accumulator element) so that the current is series-connected to the two lines of rails and closed over a relay, known as « track relay ». In the design of the track, various measures have been taken to ensure the working of the track circuits. The rails forming part of the track circuit are, at their ends, provided with suitably designed insulated joints. The individual lengths of rail are bonded by means of riveted or welded metal connections so that the electric resistance is sufficiently small at the bonding points. A resistance of several ohm is series-connected with the current supply in order to reduce the current during the passage of trains. The latter when passing over the track circuit cause the relay to be de-energised, as the relay is short-circuited. Such an installation, sanctioned by long experience and carried out hundreds of thousands of times all over the world, is still a main feature of railway safety installations in all cases where it is practicable. (We propose to ignore here the devices based on a different principle which have not found widespread acceptance, and which have no place in the present account). This device has decisive advantages which have

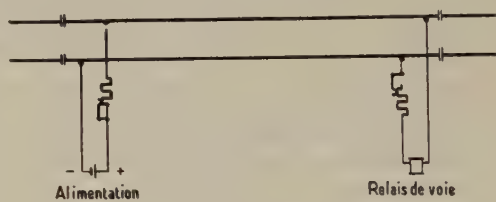

Fig. 1. — D.C. track circuit on a non-electrified line.

Alimentation = feed. — Relais de voie = track relay.

constantly widened its fields of application : low cost, remarkably long service life no matter how numerous and heavy the trains may be, extraordinary reliability of operation; any incidents such as a failure of the current supply, cutting of a wire etc. merely incur the risk of the track relay being prematurely de-energised and not the risk of improperly keeping it energised.

It is due to the track circuit (D.C. or A.C., pulsating or otherwise) that the safety installations appropriate to railway operation have acquired the degree of perfection for which they are reputed : protection of trains in stations, automatic block system, electric signalling installations with flexible working, automatic cancellation and route pre-setting — in short, the most modern, the most economic and the safest devices depend on the track circuit and would not, without it, be able to offer the advantages ascribed to them.

To complete these general data concerning the D.C. track circuit, we may mention, for the sake of greater accuracy, the electrical characteristics of the track relay long standardised on the French

(1) Also known as « insulated zone ».

railways. They are as follows : its coil resistance is 4 ohm, the minimum current required to operate its contact is 0.07 amp, and the current below which the relay is de-energized is 0.05 amp.

The D.C. track circuit is affected by another factor, not apparent in figure 1, which must be taken into consideration in the design of the installation, and that is the insulation resistance between the two lines of rails. This insulation resistance is set up by sleepers and ballast. It depends on the atmospheric conditions, on the quality of the ballast and on a number of other circumstances. It is usually assumed that the resistance can drop, on open track sections, to a minimum of 2 ohm per kilometre.

The resistance of trains shunting the two lines of rails (« *vehicle shunt* ») is never strictly zero. It can also be said that there never occurs a true short circuit at the terminals of the track relay when a train passes over the track circuit. The resistance between the lines of rails approaches a short circuit all the more closely, the greater (with the same conditions of the rail surface) the number of train axles, and the heavier their load. (A light railcar thus produces, to use current terminology, a « less effective shunt » than a train consisting of a heavy locomotive followed by numerous vehicles). Moreover, as will be explained later, the surface condition of the rails — and, in this connection, the condition of the wheel tyres — also plays its part in affecting *the track circuit shunt.*

Without going into details of the theory of the installation, it will be understood that difficulties are encountered in obtaining proper working in certain unfavourable circumstances : in particular. in the case of light railcars with a small number of axles, and in the case of the running surface being covered with an insulating film (sanded or rusty tracks).

The D.C. track circuit has been perfected in order to improve its « shunt sensitivity ». Several devices have been adopted with a view to increasing its « shunt limit », i.e. the highest resistance which, placed between the two lines of rails, still reliably causes the track relay to be de-energised. It is not proposed to describe these installations which, though some of them are of considerable interest, merely represent partial and inadequate solutions.

We have stated very briefly that there is, in certain cases, a risk that the track circuit is not properly short-circuited by the train. In other words, the « all or nothing » working (absence or presence of vehicles) merely represents a first approximation and does not correspond to actual conditions. It is the very object of the developments described in the present note to elucidate the measures taken to overcome these difficulties and to ensure the high quality of track circuit performance which is so desirable for a particularly valuable safety device.

A prolonged study and a systematic analysis of the track circuits, their failures and safety margin have clarified a problem which has been, for too long, a matter of empiricism and conjecture. This systematic investigation has been carried out on a section of line where all the enemies of the track circuit are encountered : the Caen-Cherbourg section of the Paris (Saint-Lazare)-Cherbourg line which was equipped, twenty years ago, with automatic block signalling, with D.C. track circuits; the signal lights appear when the train approaches. Any shunt failure is therefore indicated by the failure of the signal light to appear in front of the train. It was the repeated occurrence of this failure on the Caen-Cherbourg line which has given rise to the investigations and has opened the way to the adoption of the remedies discussed below.

In the systematic study of the shunt of the track circuits on a line such as Caen-Cherbourg, a serious difficulty is encountered : the shunt failures occur

sometimes at one point, sometimes at another point of the line. The track circuits concerned are numerous . If it is possible permanently to install a recording device for a given track circuit, such a procedure becomes impracticable for a greater number of installations concerned. This difficulty has been overcome by placing the recording instrument, not on the track, but in a specially designed testing car. That is why a Bugatti railcar, released from commercial operation, has been assigned to this task and has furnished most valuable information which has enabled the systematic study of the problem to proceed. For this purpose, the Bugatti railcar has several advantageous features, especially that of possessing wheels with tyres which are normally insulated against the vehicle. These arrangements have made it possible to convert the railcar into a research instrument suitable for carrying out and recording all the measurements required for the study of the working of track circuits. By coupling the testing car to another railcar the behaviour of which it is desired to study, the relevant characteristics can be recorded directly. We do not propose to describe the equipment of this Bugatti railcar, but we shall sum up the results of the test runs, not only on the Caen-Cherbourg line but also on other S. N. C. F. lines as well as on German and Swedish lines, since the German and Swedish railways have asked for the loan of the Bugatti car for test runs on some of their lines.

The main points that have come to light are these : track circuit failures which have hitherto largely remained unexplained are due to the interposition, between wheel and rail, of a film with a more or less pronounced insulating effect. These films may be due to the alternation of humidity and sunshine (a frequent case on the Caen-Cherbourg line) which causes a slight oxidation of the running surface; or they may be due to sanding from a preceding vehicle, or else to incipient corrosion of a rail on tracks which are rarely used, or which are situated at practicularly exposed places (e.g. in non-ventilated tunnels used by steam locomotives). The supply voltage of the track circuit is not without influence on the shunt effect. On the contrary, it has been proved that the insulating film requires a certain minimum potential if it is to be pierced. This film re-forms very quickly, a fact which, as we shall see later on, has suggested the use of certain new devices to improve the shunt on track circuits where difficulties are encountered.

In the light of these investigations, it has been found necessary to reconsider the very principle of the traditional track circuits, designed for trains causing a shunt of normal value.

These track circuits are fed with current of the order of the volt and the shunt resistance de-energizing the track relay is of the order of 0.10 ohm or several tenths of ohm. Now, a careful examination has shown that, even in this case, the short circuit of the track relay caused by a railcar is not generally ensured in a completely continuous manner. Oscillograph recordings have shown that the short circuit takes the form of a series of very closely spaced but nevertheless intermittent points [1]. We shall see later how this finding has been put to good use in looking for an installation where the feed consists of intermittent impulses which have special features liable to improve the shunt.

These preliminary explanations were necessary in order to bring into proper perspective, on the one hand, the recent

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[1] Other causes may intervene to render the action of railcars on track circuits intermittent, such as, in particular, vibrations that might be caused by the wheels, and the corrugation of the rails. Various investigations are in progress in order to throw light on these factors, taking into account the new means, described in the present notes, of studying the track circuits.

research work carried out by the S. N. C. F. under the auspices of the Office for Research and Experiments of the International Union of Railways, and on the other hand, the value of the installations described below. The first of these concerns a device capable of replacing, with advantage, the installations of conventional type in certain circumstances on tracks where the shunt is provided by ordinary trains. The second device, on the other hand, is reserved for difficult cases and offers a solution to problems for which no solution, or at least no solution of equal ease of application, has hitherto been available.

II. The electronic track circuit with impulse trains of musical-frequency.

Electrification with 25 kV, 50 cycles, has given rise to manifold research work with a view to using equipment which is well suited for this new system of electrification, and which is as economic as possible. On lines already equipped with automatic block signalling, the arrangement of the latter gives rise to difficulties and to expenditure of a sometimes important order. As a general rule, the automatic block system in existence before electrification is fed with direct current. The first thought coming to mind is to retain the same supply system, seeing that the current is different from that used for traction purposes. But such a solution is not always practicable; far from it. (We shall presently deal with the reasons). Moreover, this solution is accompanied by various complications. It is no longer possible to adhere to the system shown in figure 1. It becomes necessary to enable the return current to use the running rails back to the substation. For this purpose, instead of insulating the track circuit on both lines of rails as shown in figure 1, only one line is insulated, the other one being reserved for the return of the traction current. But this arrangement has a number of drawbacks : it reduces the insulation of the track circuit; it calls for the installation of spark-arresters (« spark-gaps ») between the two tracks in order to cause the tripping of the circuit breakers if the catenary should drop on the insulated line of rails; in contrast to the diagram of figure 1 the arrangement does not reliably ensure the detection of broken rails from the fact that the track relay becomes de-energised. The adaptation of D.C. track circuits is a relatively costly operation, taking into account all the subsidiary arrangements to be made. Moreover, it often happens, — as it does on a large part of the Valenciennes-Thionville line — that direct currents returning through the soil are produced in the vicinity of the railway (e.g. from electrified canal or colliery railways, tramways, or various industrial installations). As long as one does not electrify and as long as one adheres to the arrangement shown in figure 1, comprising the insulated track circuit, the stray currents are unable to circulate along the track. In contrast, if one of the lines of rails is converted into a continuous return channel, this would constitute a particularly favourable channel for the draining of stray currents. As a result, there would be constant disturbances on the track circuits. In such a case, frequently encountered in the industrial regions in the north-east, the use of direct current for the track circuits must therefore be proscribed.

In this connection, the normal solution is to use, for the track circuit feed, an alternating current with a frequency which differs from that of the traction current. The S. N. C. F. have begun by using, for the Valenciennes-Thionville electrification, a system with a frequency of 83 1/3 cycles, a frequency sufficiently remote from that of 50 cycles to make selection easy. Moreover, being nevertheless fairly close to the traction current frequency, this frequency has enabled the S. N. C. F. to use the normal 50 cycle relays which they

had in stock; a simple adaptation and adjustment was sufficient. The installation corresponds to the diagram, figure 2. It will be seen that insulation is applied to both lines of rails. At each insulated joint, an impedance bond (i.e. a coil with weak resistance and high inductance) is connected between the two lines of rails. The mid-points of the two opposite bonds are connected. In the circumstances, the traction current is divided in equal parts

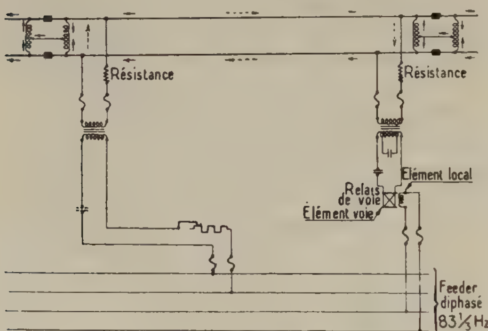


Fig. 2. — Track circuit of 83 1/3 cycle supply on a line electrified for industrial current.

Relais de voie = track relay. — Elément de voie = track element. — Elément local = local element. — Feeder diphasé = two-phase feeder.

between the two bridges of the impedance bond. The fluxes produced in these two bridges cancel each other out, being equal and opposed to each other. In contrast, the signalling current encounters the full impedance of the impedance bond coil and is thus stopped by it.

Such an installation is foolproof. It has been used on a large part of the Valenciennes-Thionville line on those sections where D.C. stray currents militate against the use of D.C. track circuits.

This solution, suitably applied, was perfectly appropriate for the equipment of the Valenciennes-Thionville line, where it also represented an economic solution because of the possibility of using standard type apparatus. In actual practice, it has proved entirely satisfactory. The equipment comprises the installation of substations where the 83 1/3 cycle current is produced from the 50 cycle current of the general supply system. These substations are linked with each other by means of cables or feeders which distribute the signalling current along the track at a voltage of about 3 000 V.

As regards the future use of equipment of this kind, more recent studies have revealed the possibility of envisaging the application of principles liable to bring about special advantages in several respects. For one thing, having regard to the findings concerning the shunt of track circuits, it is not without interest to have recourse to currents of higher frequency which would, incidentally, reduce the cost of the impedance bonds. (This is because, the higher the frequency, the more it becomes possible to reduce the number of windings of the impedance bonds, as the inductance of the circuit is proportional to the frequency used.)

It was also highly desirable to find track circuits which could be fed directly by means of a connection to the sectional current supply along the railway line so as to avoid the cost of special substations and feeders.

The solution has been found in the use of electronic valves which can take over all the functions required in the circumstances: the production of a current of musical frequency derived from the industrial current supply (transmission side); the reception, identification and amplification of the current at musical frequency transmitted to the track circuit (track relay side). We shall, moreover, see that the electronic valves used for this purpose also fulfil other functions which are equally valuable and which endow the electronic track circuit with special qualities at no extra cost.

The device adopted in consequence of laboratory tests and field tests (on the Aix-les-Bains-Annecy line) is the one proposed by the « Compagnie des Signaux

et Entreprises Electriques », French manufacturers of railway signalling equipment. In order to make the principle of this device as clear as possible, we shall base the description on a simplified diagram, before discussing the desirable additional features.

Figure 3a shows an insulated track circuit fed by a triple-electrode (« triode ») tube. (The diagram applies to a non-electrified line.) One recognises the cathode and the indirect heating device of the latter by means of a battery. The grid is connected to a polarisation battery through a transformer winding. (It is, in fact, necessary for the grid potential to be suitably adjusted so that the grid can fulfil its function as effectively as possible.) The same transformer comprises a winding connected to the track circuit, and another one series-connected with the plate and its battery. A condenser is connected to the terminals of the last-named winding. The connection diagram of this triode corresponds to that of an oscillator, the winding of the grid and that of the plate being linked to each other by means of the transformer. The latter thus produces, in the winding connected to the track, an alternating current of a frequency which depends on the electric characteristics of the elements included in the plate circuit.

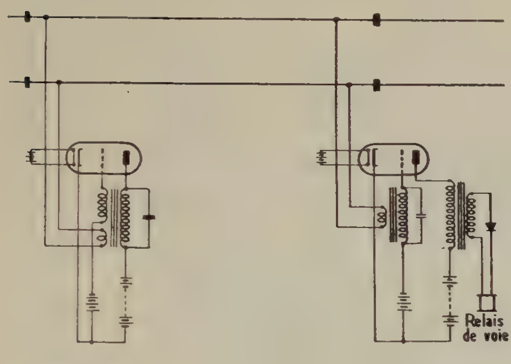


Fig. 3a. — Electronic track circuit. Simplified diagram of oscillation transmitter and amplifying receiver, using triodes (non electrified lines).

Emetteur = transmitter. — Récepteur = receiver. — Relais de voie = track relay.

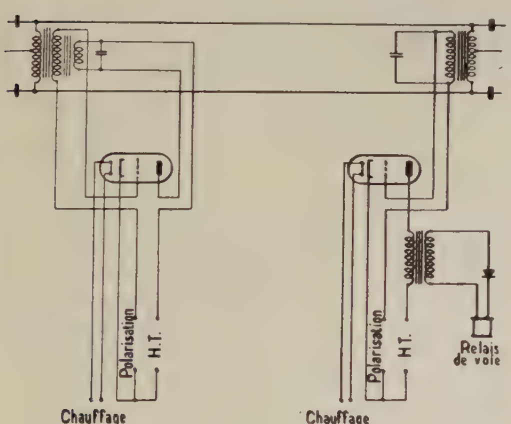


Fig. 3b. — Electronic track circuit. Theoretical wiring diagram, using triodes (electrified lines).

Relais de voie = track circuit. — Chauffage = heating.

The current at musical frequency transmitted through the track circuit is received, at the other end, at a transformer winding. On the reception side, too, one finds a triode functioning as an amplifier. The grid is connected to the secondary of the reception transformer, a condenser connected to its terminals being attuned to the frequency which is to be received and amplified. On the plate circuit, the amplified current is received by means of a transformer which feeds the track relay. (A valve is series-connected with the relay which is of a normal single-element D.C. type.)

Such a system requires the use of batteries for the heating of the filament, the polarisation of the grid and the working of the plate. Ultimately, it is of course the intention to use the sectional current supply, after filter rectification. Moreover, on electrified lines, the connection with the track will be provided through impedance bonds so as to ensure the passage of the return traction current

of the electric locomotives along the track. The impedance bond will also provide the coupling between the grid and plate circuits of the valves. Figure 3*b* shows the principle of an arrangement corresponding to these conditions. Figure 3*c* shows a similar arrangement with three-grid tubes (control grid, check grid, screen grid), which ensure a better operating quality than the triodes.

However, the conditions fulfilled by the arrangement just described must be supplemented. It is, in fact, not sufficient to transmit and receive a current at musical frequency, i.e. about 1 000 cycles, a frequency which has proved to be suitable for, and compatible with, the lengths of track circuits to be equipped, which may reach 2 km. It may be feared that disturbing effects emanating from other installations (e.g. electric machinery) may introduce a current of the same frequency into the track circuit. As a result of tests carried out on the Aix-les-Bains-Annecy line, a supplementary condition has therefore been introduced the fulfilment of which provides a complete protection against such disturbances. The idea is to transmit the 1 000 cycle current in the form of trains of intermittent impulses, i.e. with transmission intervals. The device is so arranged that this condition is met without the addition of electronic valves and without any appreciable complication. The principle is illustrated in figure 3*d*. The automatic grid polarisation circuit is so designed that the oscillations are periodically blocked for a period of time which depends on the electric constants of that circuit. As a result the impulses transmitted to the track are coded (13 millisec. of transmission, followed by 37 millisec. without transmission). On the reception side, the current coming from the track is received on the control grid by means of a detector system which eliminates the 1 000 cycle carrier. The pentode thus acts as an amplifier for a current of 20 cycle frequency. The track relay receives the amplified current by means of a system of filters and rectifiers.

The installation offers the essential

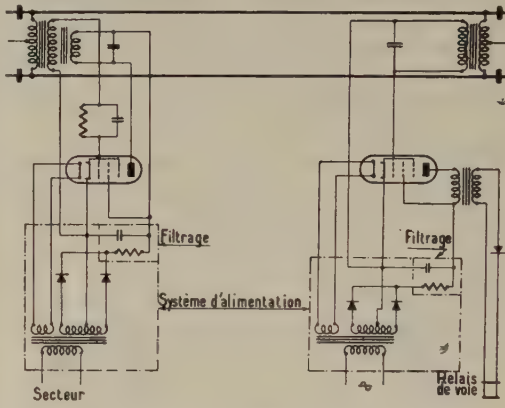


Fig. 3*c*. — Electronic track circuit. Theoretical wiring diagram, using pentodes.

Secteur = sectional current supply. — Filtrage = filter device. — Système d'alimentation = feed system. — Relais de voie = track relay.

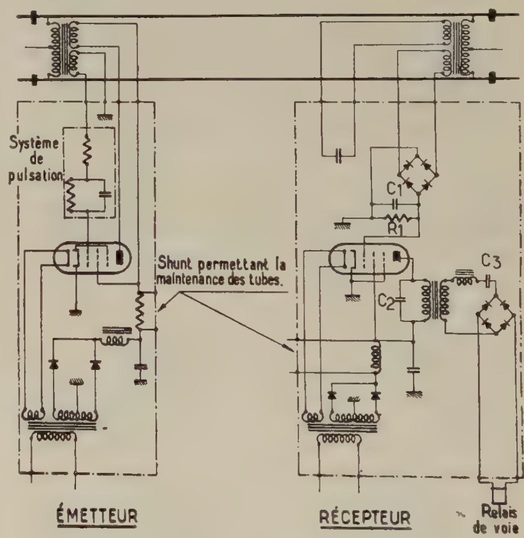


Fig. 3*d*. — Electronic track circuit. Diagram of installation with pentodes (pulsating currents).

Emetteur = transmitter. — Récepteur = receiver. — Système de pulsation = pulsation system. — Shunt permettant la maintenance des tubes = shunt permitting the maintenance of the valves. — Relais de voie = track relay.

safeguards of a track circuit of traditional type : the track relay is de-energised if the insulated joints are burnt out or if a rail is broken. The same applies if a pentode connection happens to be cut.

The arrangement adopted is simple and economic. The apparatus, on the transmission side as well as on the reception side, is accommodated in boxes similar to those used for traditional signalling installations (fig. 4). Maintenance is easy. It includes, in particular, the periodic verification of the pentode characteristics. Their modification by the maintenance staff is a very simple matter, and can be carried out without having access to the installation inside the box. The type of pentode adopted for this purpose is a valve with a long service life, of the kind normaly used for repeater stations of the telephone installations of the line.

An important problem concerns the continuity of the current supply. However reliable the sectional current supply to which the installation is connected may be, it is necessary to reckon with possible breakdowns. An economic and reliable local supply is therefore an indispensable complement of the device. For this purpose, S. N. C. F. have resorted to the use of rotary converters originally designed for their radio-electric installations at marshalling yards. (In that connection, the same problem of emergency current supply had arisen, and had been solved as a result of laborious research work.) In the circumstances, the electronic track circuit is normally fed from the traction current supply of the section which also ensures the charging of an accumulator battery. If the current supply fails, the emergency supply is immediately switched in and the converter started by means

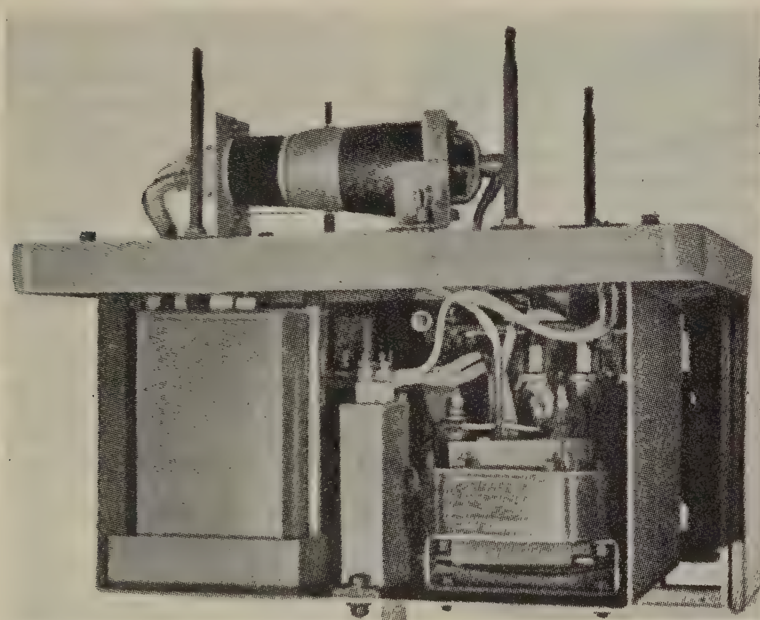


Fig. 4. — Receiver assembly of 1 000 cycle track circuit.

of a transfer relay. The transfer is so rapid that there is no time for the track relay to become de-energised, and there is no repercussion on the signals.

As a first test of these installations under service conditions, the station of Avesnes, situated between Valenciennes and Hirson, has been equipped with them since November, 1953, and the working of the installation has been entirely satisfactory. Due to this installation, important savings have been effected in the cost of the equipment in spite of the need to replace, though at fairly long intervals, the transmission and reception pentodes. Moreover, as already pointed out, the shunt obtained is of a quality which is at least equal to that of the traditional track circuits, in spite of the very low current consumption of the installation (about 50 VA compared with 150 to 200 for a track circuit at 50 or 83 1/3 cycles).

The theory of this track circuit and the predetermination of its characteristics are based on the classic equations governing the propagation along a line with uniformly distributed constants. The calculation is related to that of the transmission in telephone cables, except that in the case of cables, the capacitance is appreciable and the inductance very small (so much so that the inductance is artificially increased in order to reduce the attenuation); the loss is practically zero. With the present track circuit, it is necessary to reckon with a high loss; moreover, the inducance is appreciable, and the capacitance negligible. However, in order to adhere to simple arrangements, it was decided not to provide additional capacitances along the track to reduce attenuation, as the latter was still acceptable for the lengths of track circuits encountered in actual practice.

If the installation thus designed ensures important savings for the equipment of lines electrified at industrial current supply, it will also furnish an advantageous solution in other cases, and particularly for track circuits on lines with D.C. electrification.

The most difficult problem, that concerning the propagation of currents along the track circuit, has been elegantly solved. In the form just described, this type of installation has thus furnished an advantageous solution for the equipment of the track circuits on the main line in the north-east. Moreover, various supplementary devices are at present being studied which will, in the future, permit further extensions of the field of application of this device.

III. Track circuit with higher-voltage impulses.

To improve the operation and to reduce the cost of track circuits on lines on which the interaction between trains and track circuits is of the normal type — that has been the first objective. It was in this field that the greatest number of applications was encountered.

There remains, however, a further problem to be solved : that of the track circuits on tracks which are rarely used, or which are situated in places where the running surface is often covered with an insulating film (in particular, little used sidings, and moist and smoky tunnels).

In order to make the track circuit as effective as possible S. N. C. F. have taken into account the results of the investigation which they have carried out, and which has been outlined above. We have seen that, when an insulating film is interposed between wheel and rail, it becomes necessary to apply a voltage which is high enough to pierce this film and to cause the track relay to be de-energised. In the case of soiled rails, it is therefore not sufficient to feed the track with a potential of the order of the volt. Systematic investigations have shown that potentials of several tens of volts are required.

Now, it is obvious that, if such voltages are to be permanently applied to the track circuit, the cost of energy consumption would be very high and, in fact,

prohibitive. One has therefore thought of reducing the current consumption of the track circuit in spite of the voltage increase. For this purpose, the idea has been conceived to confine the transmission to the rails to brief and suitably spaced impulses. These suffice to pierce the insulating film interposed between wheel and rail and, in the absence of trains, to energise the track relay, whilst lowering the cost of energy considerably. It will thus be seen that the function of the impulses is not the same in the two different kinds of installation. In the case first described the transmission of impulses in intermittent trains has been resorted to in order to obtain a « coding », i.e. in order to avoid any disturbance from an outside source. In the present case, the transmission of impulses represents the elementary minimum feed required for the working of the track relay at the lowest possible cost.

a) *Thyratron track circuit.*

S. N. C. F. have carried out an installation which embodies industrial devices of recent types . This installation has been designed by M. LEROY, a Divisional Inspector of S. N. C. F. Before being assigned to the Department for Safety Installations, M. LEROY had been, for several years, in charge of the Caen Inspectorate where he had knowledge of all the failures experienced with track circuits. (We have already pointed out that the Caen-Cherbourg sections has posed particularly difficult problems in this respect.)

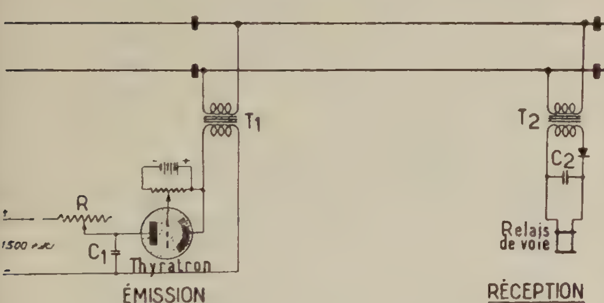


Fig. 5. — Wiring diagram of thyratron track circuit.

Emission = transmission. — Réception = reception. — Relais de voie = track relay.

The thyratron track circuit transmits to the track very short impulses at a voltage that can be adjusted. (In practice, the voltage is of the order of several tens of volts ranging from about 30 to about 100.)

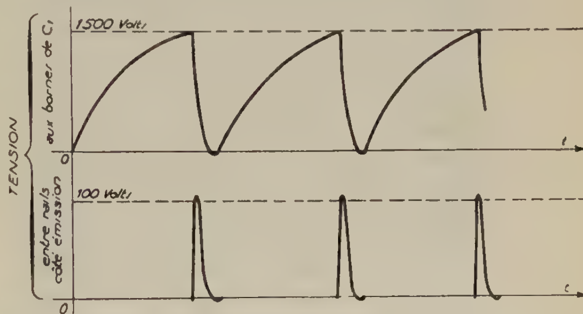


Fig. 6. — Thyratron track circuit. Voltage at the terminals of C_1 and on the transmission side of the track circuit.

Tension aux bornes de C_1 = voltage at the terminals of C_1. — Tension entre rails, côté émission = voltage between rails, on transmission side.

The feed is assured by means of a power valve generally known as « thyratron ». (This, it will be recalled is a triode with gaseous atmosphere which can pass or interrupt important currents.)

Figure 5 shows the principle of the installation. Departing from the 1 500 V D.C. supply, condenser C_1 is charged by means of the resistance R. At the moment when the potential at the condenser terminals reaches the value of the thyratron discharge voltage, the thyratron is suddenly energised and transmits an impulse to the track by means of the transformer T_1. (The grid contains an adjustable polarisation which permits the adjustment of the discharge voltage to the desired value.) The discharge continues until the voltage drops below the cut-out voltage of the thyratron. The discharge circuit is then interrupted and the cycle recommences. (This is a well-known time-controlled release device.)

Figure 6 shows the voltage at the terminals of condenser C_1 as well as the voltage on the transmission side of the track for a given setting.

The impulse thus produced has a steep front. In the course of its propagation along the track circuit, this front is inflected and the impulse assumes, from a certain distance onwards, a shape approaching that of a sinusoid. This phenomenon is accompanied by a voltage reduction.

On the reception side, a neutral D.C. relay is connected, with interposition of a transformer T_2 and a condenser C_2. A copper oxide valve serves to pass to the relay a current of a single polarity only. The impulses transmitted have the effect of charging the condenser C_2 which, between two consecutive impulses, discharges slowly to the track relay. The voltage on the reception side of the track as well as the voltage at the terminals of the track relay are shown in figure 7. With such an installation, the track circuit is polarised, which is a desirable precaution against an untimely re-feed across the insulated joints at the ends. (The cadence of the impulses is of the order of 1 to 2 per second.)

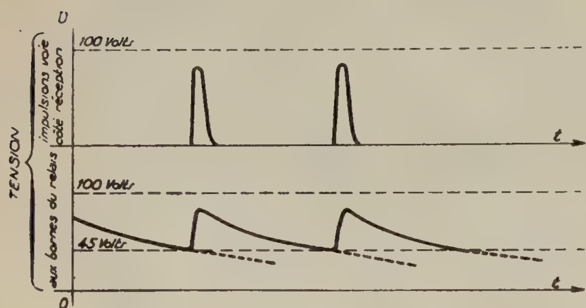


Fig. 7. — Thyratron track circuit. Voltage on the reception side of the track circuit and at the terminals of the relay.

Tension impulsions voie côté réception = voltage of track impulses on reception side. — Tension aux bornes du relais = voltage at the terminals of the relay.

The first installation of this kind has been applied to a track circuit of 1 km length in the Nettreville tunnel near Evreux, at the beginning of November 1953 (the running surface in this tunnel being particularly soiled). The experiment has been continued until April, 1954, without any failure of the installation. The thyratron used was filled with argon and had a long service life.

The consumption of this track circuit was about 250 VA.

In consequence of the good results obtained, other installations have been planned which will use recent types of thyratrons specially adapted to the working conditions encountered.

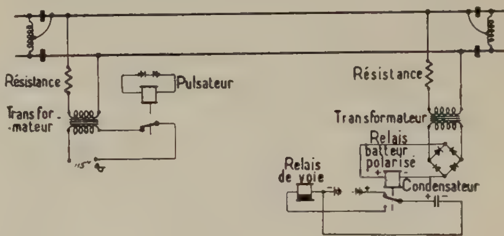


Fig. 8. — Track circuit with current impulses of 50 or 83 1/3 cycles.

Transformateur = transformer. — Pulsateur = pulsator. — Condensateur = condenser. — Relais batteur polarisé = polarised beater relay. — Relais de voie = track relay.

What are the limits for the application of this type of track circuit?

The device is so designed that the voltage at the track can be adjusted at will. It is, however, obvious that there must be a limit to the voltage increase. In practice, voltages of some tens of volts suffice to pierce the insulating films most frequently encountered. There merely remains the exceptional case of excessive sanding which may, for instance, be due to the faulty working of the sander. It would not be possible to envisage the transmission through the track of voltages high enough to pierce layers of such thickness. The solution must therefore be found by means other than the electrical apparatus : by controlling the use and output of the sanders, and by using brushes designed to remove excessive quantities of sand from the rail.

b) *Track circuit for current of 50 to 83 1/3 cycles.*

If the thyratron track circuit makes it possible to adjust the track voltage at

will, it calls for a special installation for the production of direct current to feed the plate circuit. On lines with A.C. track circuits (50 or 83 1/3 cycles), a different arrangement can be envisaged : the feed current of some tens of volts may be produced by means of a transformer connected to the general distribution feeder. This current is transmitted in the form of trains of intermittent impulses. For this purpose, a pulsator is connected on the transmission side. On the reception side, the installation includes, behind the transformer, a Wheatstone bridge rectifier unit to which a relay is connected. This relay follows the pulsations of the transmitter. These pulsations feed another relay (track relay) the de-energisation of which is retarded by means of a condenser.

Figure 8 shows the wiring diagram of this track circuit, applicable to a circuit of short length, with insulation of one line of rails only.

IV. Conclusions.

The explanations and descriptions given above serve to illustrate the developments recently applied to insulated track circuits. Moreover, the work carried out by the S. N. C. F. under the auspices of the Office for Research and Experiments of the International Union of Railways continues and will lead to further results.

However, the results already achieved, in theory as well as in practice, seem to merit a general exposition without awaiting further developments. A detailed description of the calculations and of the apparatus concerned would require long commentaries. We have merely attempted to outline the essential features of these new installations in order to make known their general principle and their field of application. As will have been seen, we are here dealing with solutions which have already been tested by now, and which are destined to play a part in very early developments.

[656 .21 (73) & 656 .25 (73)]

Progress report on New York Central. Four tracks to two, with CTC.

On 163 miles between Cleveland and Buffalo, two main tracks are being taken up and CTC installed on the two remaining tracks for train movements each way on each track.

(*Railway Age*, November 21, 1955.)

In May, the New York Central disclosed a plan for removal of two main tracks on 163 road miles of what is now four-track main line between Cleveland and Buffalo. This is being accomplished by installation of centralized traffic control for train movements in both directions on each of the two remaining tracks. Planning and early stages of construction have proceeded far enough for *Railway Age* to publish this progress report, including many details not previously available.

This CTC project, to cost $6 million, is expected to pay for itself through reductions in maintenance and operating expenses. In addition, a large quantity of 127-lb rail and ties removed from two tracks taken up will be available for use elsewhere.

The two outside tracks will be taken up. On Track 4, to be removed, the speed limit is now 50 mph, and on Track 3, to be removed, 30 mph. On Tracks 1 and 2, which are to be left in place, the speed limit has been and will continue to be 80 mph for passenger trains and 60 mph for freights. Traffic consists of 85 or more trains daily, of which half are passenger trains. Each of the four tracks was signaled for movement in one direction only, Tracks 1 and 3 westward, and Tracks 2 and 4 eastward. Passenger trains and many through freights normally were operated on Tracks 1 and 2.

Main-track crossovers.

Capacity to operate 85 or more trains daily on two tracks only is to be secured by more intensive use of these two tracks. Each is being signaled for train movements both ways. Power-operated crossovers, spaced an average of 7.3 miles apart, will be used to divert trains from one track to the other, so that idle sections of track can be used to run fast trains around slower ones.

To determine where the crossovers between the two main tracks should be located, train movements for typical days were « redispatched » on « time-distance » charts, according to what could be done with CTC on two main tracks. Then the proposed locations of crossovers were shifted according to local considerations. For example, a main track crossover and an end of a siding were spotted together to form one remote control CTC interlocking.

In the CTC territories, there will be 42 crossovers between Tracks 1 and 2. The maximum distance between crossovers is 11 miles and the minimum 4 miles. Model 5c, 110-V D.C. switch machines are to be used. Highvoltage machines will provide the fast operation essential because of the high density of traffic. All power switches are to be equipped with dispatcher-controlled snow melters.

Siding for switching.

Two-mile sections of Tracks 3 and 4 (the two outer tracks) are to be left in service as « work sidings » at towns where considerable local switching is required. House tracks and industrial spurs are connected to these sidings through hand-throw switches equipped with circuit controllers. The sidings have power switches and No. 20 turnouts, and may be used for passing trains. Their capacity allows 150-car trains to pull into the siding at 30 mph, and still have enough track length to stop short of the leave-siding dwarf signal. The CTC territory is to include 22 of these « work sidings », 12 of which are to be sections of Track 3 left in place, and 10 sections of Track 4.

Controls in one office.

The entire centralized traffic control territory is to be controlled from two machines in the dispatcher's office in Erie. One machine will control switches and signals between Bay View, N. Y. and Girard Jct., Pa. (94 miles), with one break at Erie. The break is for 11 miles between Harbor Creek and Dock Jct., these two points being CTC controlled. The west end CTC machine controls from Girard Jct. to « BR » tower at Nottingham, Ohio (63 miles) with a five-mile break through Ashtabula, Ohio. Previously existing locally controlled interlockings were retained in these « break » areas because of the large number of industrial and local switching moves.

Eleven interlockings which were either locally or remotely controlled will now be controlled from the CTC machines. Six were on the east end of the territory, at Angola, Dunkirk and Westfield, N. Y., and North East, Dock Jct., and Lake City, Pa. Five interlockings on the west end were at Girard Jct., Pa., West Crossover (Ashtabula), Madison, Painesville and Willoughby, Ohio.

These CTC machines include several outstanding features, developed by the New York Central, to simplify and expedite manipulation. On the diagram, the lever for each switch is mounted in the 1/4-in. white line which represents the track where the « turnout » joins the « straight track ». For a crossover, the lever is at the center of the white line representing the crossover. An indication lamp in the face of each switch lever is white for « out-of-correspondence » and red for « locked ». As further aid to the dispatcher to « see » the routes which he is lining up, the 1/4 in. track lines include small triangular sections which are moved to repeat the operation of switches, so that the route being lined is indicated by a full width 1/4 in. white line.

The signal levers, with their associated indication lamps, are placed adjacent to the symbol for the track the signal governs, there being two horizontal rows of signal levers — one above the track diagram and the other below. The levers are located on the diagram at places corresponding to the signals in the field.

If two or more following trains are to use the same route through a CTC interlocking, the dispatcher can set up « fleet » control by throwing the signal lever and then raising a toggle switch immediately above that lever. This removes « stick control » so that after the passage of one train, the signal will again clear for the next one, without further attention by the dispatcher. No manipulation, other than ordinary operation of a lever, is required to control a call-on aspect.

In many CTC projects, train occupancy of a section of several miles between crossovers or siding layouts is indicated by only one or perhaps two track-occupancy lamps on the dispatcher's diagram. In order that NYC dispatchers may know exactly of the location and progress of each train, the new machines have a track-occupancy lamp corresponding with each automatic block.

Power crossovers and sidings will be included in the new centralized t

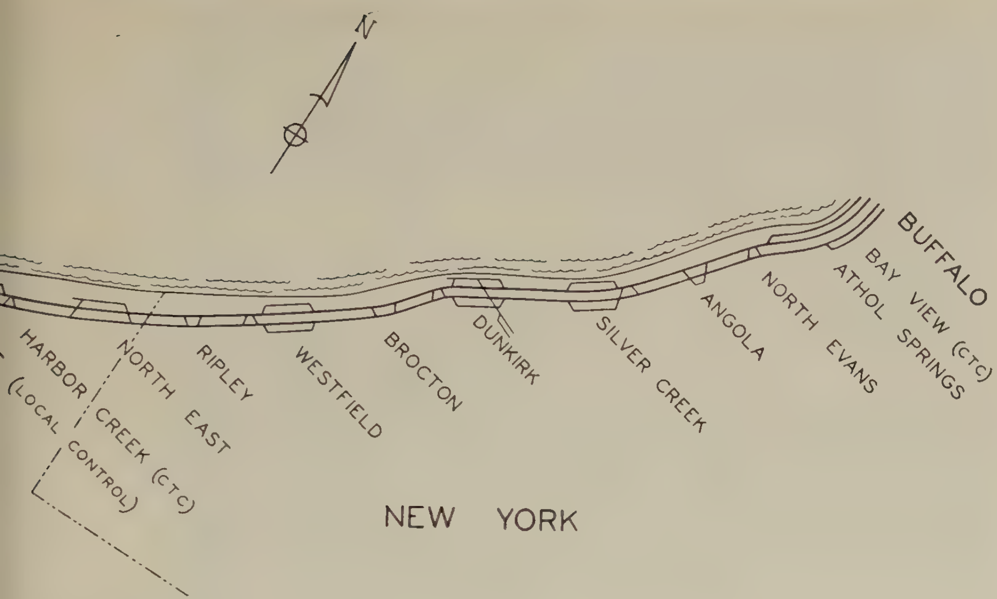
This is the first large installation employing Syncroscan for the transmission of controls and indications. Controls are sent in 1 1/2 sec. Scanning of field stations gives the dispatcher a continuous check of indications with a maximum delay of 4 seconds after change. The system is duplex in operation, in that controls and indications may be transmitted simultaneously without interference.

Longer blocks, fewer aspects.

The previous single-direction automatic signaling on all four tracks included four-aspect signals with blocks about 5 200 ft long. The new automatic signaling for both directions on each of the two tracks is to use three aspects with blocks about 10 000 to 12 000 ft long. In approach to stations where passenger trains stop, such as Dunkirk, Erie and Ashtabula, signal block length is adjusted and appropriate signal indications are provided on both main tracks so that trains can close up without unnecessary stops. The intermittent inductive train stop system, including wayside inductors at all main track automatic and interlocking signals, is being revised according to the new locations and controls of wayside signals.

Flashing aspects for crossovers.

To direct enginemen to bring their trains up to and through the crossovers at the speeds for which they are designed, special aspects are included in this new CTC project. If a route includes a diverging move on a No. 20 crossover reversed (good for 45 mph), the home signal aspect is red over flashing green over red, which indicates proceed, limited speed within interlocking limits. If only one block ahead is unoccupied, the home signal aspect is red over flashing yellow over red, indicating proceed at limited speed, prepared to stop at next signal. Limited speed is 45 mph. The approach signal will display yellow over flashing



ol system except locally controlled interlocking at Ashtabula and Erie.

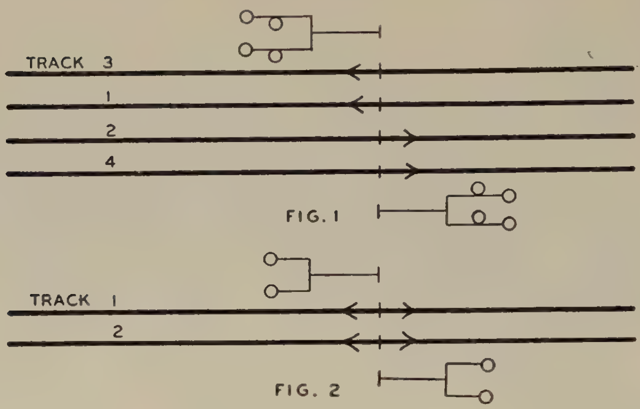
green to indicate approach the next signal at limited speed.

If the turnout is a No. 16, then the home signal will display medium speed aspects for crossover moves; i.e., red-green-red indicating proceed, medium speed within interlocking limits; or red-yellow-red, to indicate proceed at medium speed preparing to stop at next signal. The approach signal will display yellow-green to indicate approach the home signal at medium speed. Medium speed is 30 mph.

The sidings are track circuited, not only to control track occupancy lamps on the dispatcher's diagram, but also to control signals. The turnouts to sidings are No. 20, signaled for entry at 30 mph. The aspect for a train to enter an unoccupied siding is red-yellow-red, proceed at medium speed preparing, to stop at next signal. The approach signal will display yellow-green to indicate approach next signal at medium speed. If the siding is occupied, the dispatcher can still line a route into it, in which case the home signal will display red-red-yellow to indicate proceed at restricted speed (15 mph). The approach signal will display yellow-red to indicate proceed prepared to stop at next signal, trains exceeding medium speed must reduce to that speed. The leavesiding dwarf may display four aspects; flashing green, proceed at limited speed within interlocking limits; flashing yellow, proceed at limited speed prepared to stop at next signal; yellow, proceed at restricted speed; and red for stop.

Code line strung by machine.

Several phases of the early construction work are being carried on simultaneously — for example, staking out on the ground of the remote interlocking (crossover locations); taking automatic block signals out of service; and rearranging the track circuits for the highway crossing protection for high-speed train



Before CTC: Fig. 1 shows signaling for single-direction operation of trains on each of four main tracks. After CTC: Fig. 2 shows signaling for either direction movements on each of two main tracks. Service road will be outside tracks.

Old automatic signal taken out of service with light units turned to the field. The track next to the signal will be removed, with a service road in its place.

movements in either direction on both main tracks. One of the earlier portions of the construction work was the lengthening of blocks, by the simple process of taking every other automatic signal out of service, a total of 198 such signals being removed.

The CTC code line wires are being strung by a special machine which is basically a derrick with a 53-ft boom mounted on a track car. The boom is telescopic so it can be lengthened to 61 ft, or it can be shortened to 15 ft. The wire feeds from the reels, and pays out through sheaves at the end of the boom, being laid up on the top crossarm.

A track motor car pulls the derrick car and the two track cars with the line wire reels (5 000 ft of wire per reel). Using this mechanized operation, the line gang can string three miles of code line per hour. A patent has been applied for on this machine, which was designed by L. A. Jackson, field signal engineer, and O. H. Steffens, signal construction supervisor, and built in the Ashtabula shop of the NYC under the direction of H. A. Smolka, departmental foreman.

Wire stringing machine allows 3 miles of code lines wire to be strung per hour by one wire gang.

Fifteen months to install CTC.

The construction is now well under way, and the project is scheduled for completion by September 2, 1956. Twenty-three cut-ins, each including 8 to 10 miles, will be made beginning at Buffalo and Cleveland, working toward Erie. After each cut-in is made, sections of Tracks 3 and 4 between sidings will be removed. The roadbed of these former tracks will be graded as a service road for off-track equipment.

The engineering, circuit design and installation work is being done by railroad forces under the jurisdiction of H. A. Scott, chief signal engineer. The major items of signaling equipment are being furnished by the General Railway Signal Company.

[385. (06 .111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association.

ENLARGED MEETING OF THE PERMANENT COMMISSION
(The Hague-Scheveningen, 1956).

LIST OF QUESTIONS

for discussion

WITH THE NAMES OF THE REPORTERS.

SECTIONS I AND III : WAY AND WORKS — WORKING.

QUESTION 1.

Research on the economic usefulness and the technical opportunity to install a third track, serving for common use (banalisation), in addition to sections of double track lines with heavy traffic, instead of installing two double track lines on such sections.

Consequences of the installation of a third track for use in either direction on the conditions necessary to insure the safety of train movements.

Reporters :

English speaking countries :

Ir. V. J. M. DE BLIECK, Chief Signalling Engineer, Netherlands Railways; Utrecht.

Other countries :

Ing. E. TENTI, Inspecteur en Chef du Service du Mouvement des Chemins de fer de l'Etat italien; Piazza della Croce Rossa, Roma, and

Ing. A. RIGGIO, Inspecteur en Chef du Service de la Voie des Chemins de fer de l'Etat italien, Piazza della Croce Rossa, Roma.

SECTION II : LOCOMOTIVES AND ROLLING STOCK.

QUESTION 2.

In a system of standard, narrow or broad gauge lines which has Diesel traction for shunting and for main line working, what are the conditions governing :

1° the choice of the characteristics and kind of transmission;

2° the most economical organisation, maintenance and operation.

Research into savings that might be possible in comparison with steam traction.

Reporters :

English speaking countries :

R. F. HARVEY, Chief Operating and Motive Power Officer, British Transport Commission; 222, Marylebone Road, London, N. W. 1.

Other countries :

R. BIAIS, Ingénieur en Chef, Chef du Service du Matériel et de la Traction de la Région du Sud-Ouest de la Société Nationale des Chemins de fer français; 41, Boulevard de la Gare, Paris (13e).

SECTION IV : GENERAL.

QUESTION 3.

Development of railway tariffs.

Economic justification of these tariffs.

Adjustment of tariffs to the new conditions of the general economic system and to the competition of the other forms of transport.

Function of tariffs in coordination of inland transports.

Reporters :

English speaking countries :

Dr. O. MAIER, Hauptverwaltungsrat, Referent für Internationales Eisenbahnfrachtrecht und für Internationale Güter- und Tiertarife der Hauptverwaltung, Deutsche Bundesbahn; Platz der Republik 43, Frankfurt (Main).

Other countries :

L. ANTOINE, Directeur du Service Commercial de la Société Nationale des Chemins de fer belges; Halte Centrale, Cantersteen, 4, Bruxelles.

SECTION II. LOCOMOTIVES AND ROLLING STOCK.

QUESTION 6.

Is a system of standard, uniform or interchangeable parts [illegible] regarding the [illegible] for locomotives and rolling stock [illegible]:

1° the choice of the characteristics and kind of traction;

2° the most economical organisation, maintenance and operation.

Research into savings that might be possible in comparison with steam traction.

[illegible]

R. F. HARVEY, Chief Operating and Motive Power Officer, British Transport Commission, 222, Marylebone Road, London, N. W. 1.

(Continental)

R. BEAU, Ingénieur en chef adjoint du Matériel et de la Traction de la Région du Sud-Ouest de la Société Nationale des Chemins de fer français, 41, Boulevard de la Gare, Paris (13e).

SECTION IV. — GENERAL.

QUESTION 10.

Development of railway traffic.

Economic justification of [illegible].

Adjustment of tariffs to the new conditions of [illegible] created by the competition of the other forms of transport.

Function of tariffs in coordination of inland transports.

Reporters:

[illegible]

Dr. D. [illegible], [illegible], Referent für [illegible] und für [illegible] der Deutschen Bundesbahn, Platz der Republik, Frankfurt (Main).

(Continental)

[illegible] mins de fer belges, [illegible] Bruxelles.

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